POWER PLANT ENGINEERING

Established Over 31 Years

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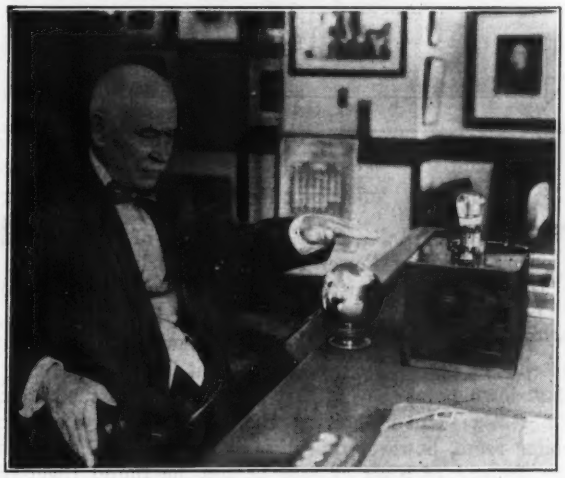
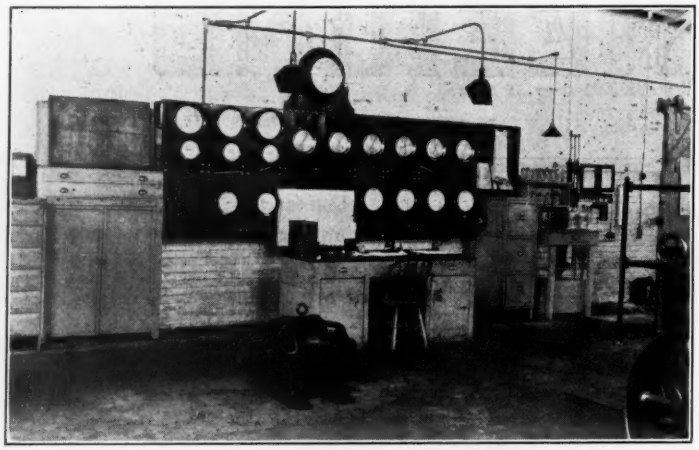


Aladdin's Lamp, 1927 Model

WHEN JUDGE GARY gracefully waved his hand over the silvered sphere on his desk (fortunately the photographer dropped into the Judge's office for a smoke at just the right moment to catch him in the act) he put into action a circuit which Rube Goldberg in his wildest dreams never equaled. In fact, this same Mr. Goldberg, the mechanical genius of the Comic Artists' Union, blushed like a schoolboy when he read of this feat and realized how truly amateurish his efforts of imagination have been.

Vacuum tube, telegraph and radio were utilized in this remote control demonstration. The electric currents, diving under the Hudson River from New York to Newark, then through the air to Pittsburgh, blithely singing "Oh, we're the berries, Lindy," were forced to earth and completed the journey by wire. Arriving at the Homestead plant, they swarmed over the huge switch and slowly, inch by inch, closed it to start the big electrified steel mill.

Now, although one great purpose of a steel company is to furnish the brokers with stock for trading and to issue bonds with coupons for the investors to clip, it must maintain appearances, so engineers, mechanics and others who must work for a living are employed to make steel, among other things forged boiler drums, which have been so important in the development of high-pressure power plants. The purpose and method of construction of these drums are described on page 771 by a man intimately connected and familiar with both the steel and power industries.



Pottery Plant Maintains 80 Per Cent Boiler Efficiency

EXCELLENT PERFORMANCE AT PLANT OF THE ONONDAGA POTTERY CO. AT SYRACUSE THE RESULT OF CONSTANT WATCHFULNESS AND ATTENTION TO DETAIL

WHEN A REPRESENTATIVE of the editorial staff of Power Plant Engineering visited the power plant at the Court Street Pottery of the Onondaga Pottery Co. at Syracuse, N. Y., some time ago, he was somewhat dismayed to note, as he approached the plant, that it was apparently shut down. Not the slightest trace of smoke issued from the stack. Upon entering the plant by way of the boiler room, however, his dismay gave way to surprise for, instead of a set of cold boilers, he found them in full operation, and everybody busy. What was the mystery of the smokeless stack?

As is the case with most mysteries, when explained, it proved to be no mystery at all, unless 80 per cent efficiency is to be considered a mystery. Notwithstanding the fact that this plant has neither air preheaters nor economizers, nor water-cooled furnaces of any kind, this power plant, which has only two 300-hp. boilers, maintains a steady combined boiler and furnace efficiency of from 79 to 80 per cent! This is no idle claim for numerous records are available to substantiate it.

FIG. 1. A VIEW OF THE SMOKELESS STACK AT THE PLANT OF THE ONONDAGA POTTERY CO.

Before discussing the factors which are responsible for this high efficiency it is of interest first to describe the mechanical features of the plant.

The Court Street factory was erected in 1921 and the buildings now completed constitute approximately one-fifth of the ultimate plant. The power plant is a brick and steel structure, comprising a boiler room and an engine room conveniently located on a railroad siding adjacent to the factory buildings. All equipment is installed on one floor, level with the grade, and there is no basement.

At the present time, two 300-hp. Connelly boilers supply steam for all process work in the factory, as well as that used by the engine for the generation of electricity.

The boilers are fired by Westinghouse, 3-retort stokers, both driven by a Westinghouse 4½ by 4-in. vertical engine. Forced draft is supplied by a duplex conoidal Buffalo Forge Co. forced draft fan, driven at one end by a Westinghouse steam turbine and at the other end by a General Electric 440-v., 25-hp. induction motor. Each boiler has 6 units of Vulcan soot blowers, Yarway combination blowoff valves, two 3½-in. Scott safety valves, Reliance gage columns and Nelson non-return valves.

Water for boiler feed is lake water, treated in a Cochrane hot process softener having a rated capacity of 5000 gal. per hr. The raw water is heated in a double compartment heater mounted on top of the sedimentation tank and, after being treated, is delivered into the boilers by either of two American-Marsh 10 by 6 by 12-in. boiler feed pumps fitted with Mason pump governors. No feed water regulators are installed at the present time, although their installation is contemplated in the near future.

Electricity for all power and light is generated by either of two engine-driven generating units. One of these is an Ames horizontal uniflow engine, rated at 320 hp., direct connected to a Westinghouse 250-kv.a., 440-v., 3-phase, 60-cycle generator having a 12-kw. belt connected exciter. The other is an Ames 4-cylinder, vertical uniflow engine, 14 by 16 in., rated at 800 hp., direct connected to a 625-kv.a., 480-v. Westinghouse generator with direct-connected exciter. There is also a third 60-kv.a. generating unit installed but this is not used at present and will be removed.

Rapid Growth of Plant Demands Larger Generating Unit

When the plant was first built only the 320-hp. and the small 60-kv.a. units were installed. The 320-hp. engine, it was thought, would carry the day load and the 60-kv.a. machine, the night load. The factory grew rapidly, however, and only a short time elapsed before more capacity was needed and the 800-hp. vertical unit was purchased. This left the 320-hp. engine to carry the night load, so the small 60-kv.a. unit was no longer needed.

From the foregoing brief description of the mechanical equipment it will be evident that there is nothing in this plant which is radically different from many other industrial plants. The high economy obtained is due entirely to the manner in which the plant is operated and in the care which each detail of the operation receives. An excellent group of instruments is provided, the readings and records of which are carefully analyzed and the information so obtained applied to operation. Mr. Eklund, the chief engineer, has developed a comprehensive system of records which show the status of operation at any time and, if it is noted that any part of the plant is not functioning normally, steps are taken to correct the trouble.

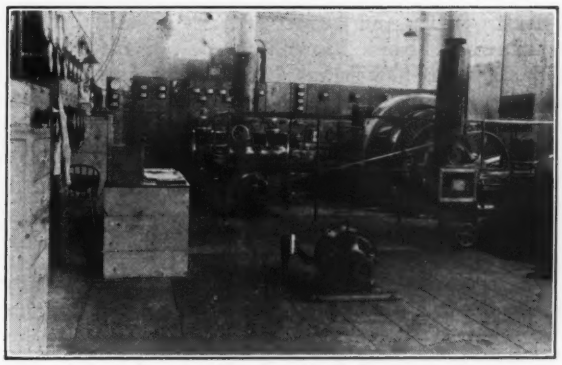


FIG. 3. IN THIS VIEW OF THE ENGINE ROOM, THE 320-HP. HORIZONTAL UNIFLOW ENGINE IS SHOWN IN THE REAR

Although automatic stokers are installed, no coal handling equipment is provided. This, it is realized, is a disadvantage but under present conditions with only two boilers and a boiler room force which could in no way be decreased by the use of coal handling apparatus, it is unlikely that the economy would be improved if such equipment were installed. When more boilers are added, however, coal handling equipment will be provided.

The lack of coal handling equipment does not prevent an accurate check being kept upon the quantity of coal consumed. Before shoveling the coal into the stoker hoppers it is first shoveled into bins of known capacity. From the number of bins so filled the total hourly or daily coal consumption is easily determined.

The coal used runs about 14,000 B.t.u. per lb. with about 7 per cent ash, but in order to be certain analyses of the coal are made for each car received. Instruments provided to check boiler operation consist of Republic draft gages (a separate gage for 1, pressure under fire

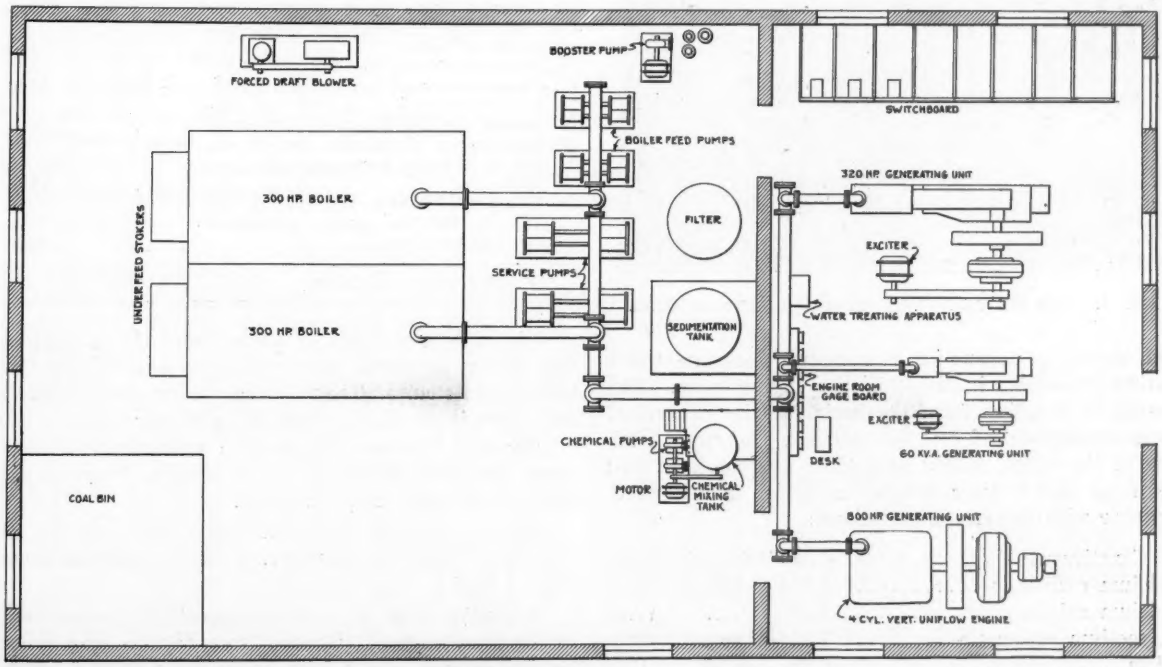


FIG. 2. PLAN SHOWING ARRANGEMENT OF PRINCIPAL EQUIPMENT IN THE POWER PLANT

2, draft over fire and 3 draft pressure in stack), Crosby steam pressure gages, Brown duplex electric CO_2 meters, Republic steam flow meters, Brown flue gas temperature recorder and Brown recording thermometer for feed water temperature. Beside these, there are also a number of pressure and vacuum recorders made by the Taylor Instrument Co.

Feed Water Tested Every Three Hours and Treated by Lime Soda Process

The condition of feed water is watched carefully. A sample of the treated water is taken every three hours

FIG. 4. BOILERS ARE FIRED BY UNDERFEED STOKERS

and tested by means of a standard Cochrane water testing apparatus installed in the engine room. The results of this test form the basis for the amount of chemicals introduced into the softener. A typical analysis of the water, before and after treatment, as well as of the boiler water, which consists of treated water together with returns, is as follows:

Constituent	Raw	Softened	Boiler
Calcium carbonate	5.01	0.29	trace
Calcium sulphate	1.05	....	.....
Magnesium carbonate	1.52	trace	trace
Silica	0.29	1.58	2.92
Iron oxide and aluminum	trace	0.06	trace
Sodium carbonate	....	2.10	7.41
Sodium sulphite	....	0.47	21.05
Sodium chloride	0.35	0.12	3.15
Sodium hydrate	....	....	30.00
Volatile and organic	0.70	1.23	15.30
Total solids by evaporation	8.93	5.83	79.90
Suspended matter	trace	trace	8.87
Free carbon dioxide	0.23	....	.....

This particular analysis, however, was made some years ago before the quantity of return water was as large as it is today. At the present time all returns from the heating system as well as from process work in the pottery are pumped back to the power plant. These returns are not treated but are sent to one of the compartments in the feed water heater and then sent direct to the boilers. So well is this accomplished that the return water forms about from 75 to 90 per cent of that fed to the boilers. The feed water temperature is always maintained over 212 deg.

Test Results on the 4-Cylinder Uniflow Engine

	Condition as to back pressure..lb.	3.4	0.0
1.	Duration .....hr.	4.0	3.0
2.	Total feed water uncorrected...lb.	33,058	23,427
3.	Feed water per hr., uncorrected, lb.	8,264	7,809
4.	Correction for 1.4 per cent moisture per hr.....lb.	116	109
5.	Correction for leakage losses per hr. .....lb.	286	286
6.	Dry steam supplied to engine per hr. .....lb.	7,862	7,414
7.	Boiler gage, uncorrected for water col. .....lb.	171	171
8.	Throttle pressure, based on calorimeter gage .....lb.	160	160
9.	M. E. P. by indicator diagram..lb.	25.0	26.7
10.	Rev. per min.....r.p.m.	300	300
11.	Ind. hp. developed.....i.hp.	368	393
12.	Total kw-hr. by integrating watt-hour meter .....kw-hr.	825	631
13.	Average kw. load (not including exciter)* .....kw.	206.2	210.3
14.	Average electrical hp. output...hp.	276	282
15.	Proportion of load to rated capacity of gen.	0.41	0.42
16.	Steam consumed per i.hp. hr....lb.	21.4	18.9
17.	Steam consumed per kw-hr.....lb.	38.1	35.3
18.	Steam consumed per i.hp. hr. calculated for 175 lb. press at throttle	.....	18.4
19.	Guaranteed steam per i.hp. hr. at 175 lb. throttle press. and 250 kw. load	.....	18.0
20.	Guaranteed steam per i.hp. hr. at 175 lb. throttle press., calculated for 210 kw. load.....	.....	18.4

*Exciter load = 11.3 kw.

The high percentage of returns and the method of feed water treatment has resulted in exceedingly low boiler maintenance. The tubes have never been turbined and there is no scale accumulation of any kind.

The soot blowers are operated twice every 24 hr., every morning and night at 6 o'clock. Boilers are blown down three times in 24 hr.

Ash is removed from the boiler ash pits by an American steam jet conveyor, which is operated three times a day.

A general idea as to the arrangement of equipment in the plant may be obtained from Fig. 2. The boiler headers connect into a main boiler room header, which in turn connects with the main header in the engine

POWER PLANT RECORD ONONDAGA POTTERY CO. COURT ST. PLANT. DATE: JAN. 5, 1927

TIME	OUTSIDE TEMP. DRY	OUTSIDE TEMP. WET	PUMP TEMP.	TANK TEMP.	HEAT SYSTEM TEMP.	HEAT SYSTEM PRESS.	RETURN TEMP.	VACUUM	WATER PRESS.	BOILER PRESS.	BOILER NO.1 CO_2%	BOILER NO.1 STACK TEMP.	BOILER NO.2 CO_2%	BOILER NO.2 STACK TEMP.	STM. STAND PIPE			VOLTS	AMPERES D.C.	AMPERES A.C.	KW.	P.F.
7 A.M.	28		208	215	219	0	142	16	50	180			15.00	560	15			460				
9 "	29		208	218	222	¼	140	16	56	180			15.00	600	11			460	100	300	185	75
11 "	24		210	218	221	0	134	17	46	180			14.00	600	12			460	100	315	140	72
1 P.M.	25		210	218	222	¼	140	17	55	180				620	24			460	100	325	200	74
3 "	23		210	216	220	0	142	17	57	180				610	25			460	100	300	180	71
5 "	24		208	216	224	2	150	17	60	180								460	80	220	150	76
7 "	24		208	217	219	¼	140	15	54	180			11.50	625	24			460	85	160	100	79
9 "	22		209	217	219	¼	140	15	54	180			15.00	620	25			460	80	110	70	70
11 "	22		208	216	220	¼	142	15	56	180			15.00	600	23			460	80	110	65	80
1 A.M.	20		208	216	220	¼	142	15	64	180			15.00	600	24			460	80	110	65	70
3 "	20		208	216	220	¼	142	15	62	180			15.75	565	23			460	80	110	63	70
5 "	18		208	216	221	¼	140	15	60	180				600	20			460	82	135	85	74
TOTAL																						
AVERAGE	24		209	216	221	¼	142		57	180			13.36	591								72

BOILER NO.1	DAY	NIGHT	TOTAL
AVERAGE BOILER HP PER HOUR			
PEAK " " " "			
LB. COAL BURNED			
LB. COAL PER HOUR			
LB. COAL PER 1000 LB. STEAM			
LB. STEAM GENERATED			
" " " PER HOUR			
" " " LB. COAL			
BOILER NO. 2			
AVERAGE BOILER HP PER HOUR	433	409	421
PEAK " " " "	600	600	600
LB. COAL BURNED	15,000	15,000	30,000
" " PER HR.	1250	1250	1250
" " " 1000 LB. STEAM	46.15	102.04	44.01
LB. STEAM GENERATED	156,060	147,240	303,300
" " " PER HR.	13,005	12,270	12,637
" " " LB. COAL	10.40	4.81	10.11
TOTALS			
KW. HOURS PRODUCED	1920	860	2780
AVERAGE BOILER HP PER HR.	433	409	421
PEAK " " " "	600	600	600
LB. COAL BURNED	15,000	15,000	30,000
" " PER HR.	1250	1250	1250
" " " 1000 LB. STEAM	46.15	102.04	44.01
" " " KW. HR.	7.81	17.44	10.81
LB. WATER TO BOILERS			
LB. STEAM GENERATED	156,060	147,240	303,300
" " PER HR.	13,005	12,270	12,637
" " " LB. COAL	10.40	4.81	10.11
" " " KW. HR.	81.26	171.21	107.35
" " FOR POWER	71,100	35,850	106,950
" " " " PER KW. HR.	37.03	41.68	38.47
" " " " I.HP.	21.16	23.82	21.98
" " " HEAT SYSTEM	84,960	111,390	196,350
" " " AUXILLARIES			

BOILER NO. 3	DAY	NIGHT	TOTAL
AVERAGE BOILER HP PER HR.			
PEAK " " " "			
LB. COAL BURNED			
" " PER HOUR			
" " " 1000 LB. STEAM			
LB. STEAM GENERATED			
" " " PER HR.			
" " " LB. COAL			
BOILER NO. 4			
AVERAGE BOILER HP PER HR.			
PEAK " " " "			
LB. COAL BURNED			
" " PER HR.			
" " " 1000 LB. STEAM			
LB. STEAM GENERATED			
" " " PER HR.			
" " " LB. COAL			

	DAY							NIGHT						
	A.M.				P.M.			A.M.				P.M.		
	NO.1	2	3	4	1	2	3	4	NO.1	2	3	4	1	2	3	4
BOILER BLOWN		6:00				4:20					1:45					
FLUES "		9:10							5:30							
COLUMNS "		8:05							6:20							
ASHES "						4:15				10:10						
FIRES CLEANED		10:15				5:00				7:20						
TANK FLUSHED		8		1				4		7		11	1		8	
" CHARGED																
FILTER WASHED																
STAND PIPE FILLED																
" " TEMP																
STOKER GREASED																
SOOT BLOWN																

GENERATOR HR.	DAY	NIGHT	TOTAL
NO. 1		12	12
NO. 2	12		12
NO. 3			

LITHO-PLANT TEMP					
TIME	DRY BULB	WET BULB	DEW POINT	AIR	VAC.
6 A.M.	71	61	52	15	14
10 "					
2 P.M.					
5 "	71	61	53	15	13
7 "	71	61	52	15	13
10 "	71	61	52	15	13
1 A.M.	71	61	52	15	13
4 "	71	61	52	15	13
D.B. TEMP					
6 A.M.	75	62	72	56	
6 P.M.	72	60	70	58	
1 A.M.	74	64	72	58	
9 A.M.	73	64	68	58	

REMARKS

PUT ON ONE MORE NOTCH AT 1:40 A.M.

BELT ON CO_2 BROKE TWICE, 7:00 P.M. 4:50 A.M.

TEMP AT LOWER END WAS GOING DOWN SO PUT ON MIDDLE FAN AT 4:10 A.M.

DAILY RECORD OF WATER TREATMENT

WATER FROM SOFTENERS							WATER FROM BOILERS			
TIME	BOTTLE NO.	P.H. VALUE	MO. VALUE	TEMP WATER	DIFF. PRESS.	BOILER NO.	C.C FOR M.O.	GRAINS/GAL. ALKALINITY	C.C. REQUIRED	GR/GAL SODIUM CHLORIDE	GR./GAL. CONCENTRATION
7 A.M.											
1 P.M.											
4 "											
7 "											
10 "											
1 A.M.											
4 "											
AVERAGE											
AV. DAY PREVIOUS											

FIG. 5. DAILY RECORD SHEET USED IN COMPILING PERFORMANCE DATA

room. When the plant was first started and before the 4-cylinder engine was installed, the engines connected directly with the boiler room header. This arrangement was not satisfactory, however, for it gave rise to severe vibration. So when the new engine was installed, an engine room header was also installed and connected as shown in the drawing. This solved the vibration problem.

Another feature of interest in connection with the new engine is the test made on its operation when it was first installed. The data obtained in this test are shown herewith. The steam consumption at 160 lb. steam pressure and 3.4 lb. back pressure, it will be noted was 21.4 lb. per indicated horsepower, while at atmospheric pressure, it was 18.9 lb. per i.hp. In making this test the utmost care was exercised to insure accurate measurements and to make proper corrections whenever necessary. In the course of preparation for measuring the discharge of the two traps which drained the steam header and vertical separator, it was discovered that these traps were carrying away not only condensate but a large quantity of steam as well. During the tests this waste was kept down to a minimum by choking the trap valves and throwing the traps themselves out of commission. Readings of instruments and indicator diagrams were taken every 20 min. The indicating watthour meter which showed the amount of current used had recently been compared with a standard and reported correct by the Syracuse Lighting Co. Feed water totals and watthour totals were checked up at the end of tests and agreed upon.

Mr. Eklund, the chief engineer of this plant, has spent considerable time and study devising a system of records suitable for his needs and, while no system of

ONONDAGA POTTERY COMPANY COURT STREET PLANT
MONTH OF FEBRUARY 1927 POWER PLANT RECORD HARRY EKLUND, CHIEF ENG'R

DATE	BOILER HOURS ACTIVE NO.1	BOILER HOURS ACTIVE NO.2	BOILER HOURS BANKED NO.1	BOILER HOURS BANKED NO.2	GENERATOR HOURS NO.1	GENERATOR HOURS NO.2	CO_2 PERCENT NO.1	CO_2 PERCENT NO.2	STACK TEMP. NO.1	STACK TEMP. NO.2	WATER PRES.	WATER TANK TEMP.	WATER PUMP TEMP.	HEATING SYSTEM STM. PRES.	HEATING SYSTEM STM. TEMP	HEATING SYSTEM RETURN TEMP.	BOILER HP HOURS AVERAGE	BOILER HP HOURS PEAK	OUTSIDE TEMP DRY	OUTSIDE TEMP WET	KW. HOURS PRODUCED	COAL PER DAY	COAL PER HOUR	COAL PER KW.HR	COAL PER 1000 LB. STEAM	STEAM TOTALS LB. STM. GENERATED	LB. STM. PER HR.	LB. STM. PER COAL	LB. STM. PER K.W.H.	STEAM FOR POWER LB. STM. FOR ENG.	LB. STM. PER K.W.H.	LB. STM. PER I.H.P.	STEAM FOR HEATING & AUX.
1	24			24	12.08		524		51	218	209	1	223	151	360	600	33		2400	27500	1192	4.96	100.73	273780	11407	9.46	4.96	1332150	55.76	23.86	19.2330
2	24			24	11.91		585		51	219	210	1½	223	145	402	600	26		2450	27500	1147	4.32	99.82	281800	12071	10.59	4.89	1622150	67.59	27.69	16.1530
3	24		12	12	10.72		567		54	219	210	1	222	150	401	600	31		2400	30000	1250	10.34	104.17	288720	12030	9.63	4.96	1311100	45.21	29.83	15.1620
4	24		12	12	10.97		589		51	219	210	1	223	146	448	600	17		2120	30000	1250	11.03	99.59	318600	13275	10.62	5.12	1286200	46.34	26.34	14.2080
5	24			24	9.62		572		51	218	206	1	223	144	457	600	19		2410	32500	1354	13.48	96.76	329090	13710	10.12	5.53	1306500	43.01	29.56	12.5390
6	24		18	6	12.63		553		52	218	209	1	222	140	374	600	31		1550	27500	1147	17.74	100.73	273060	11377	9.93	4.96	1096400	42.92	24.52	16.1530
7	24			24	12.05		573		50	218	209	½	222	149	407	600	29		2670	32500	1354	12.16	110.92	293190	12216	9.02	4.96	1196400	42.92	24.52	17.6510
8	24			24	12.19		594		58	220	210	1½	225	145	367	600	33		2530	25000	1042	9.88	99.64	264600	11025	10.95	4.96	1009100	39.65	22.67	16.9880
9	24			24	12.21		590		55	218	210	1	222	149	358	600	33		2720	25000	1042	9.15	96.89	257160	10740	10.31	4.96	1191150	41.96	23.68	19.5610
10	24			24	12.01		595		56	218	209	1	223	149	379	600	27		2460	27500	1147	11.18	108.23	269260	11220	9.78	4.96	1143500	46.96	26.55	15.9160
11	24			24	11.64		537		54	217	207	1	222	142	365	600	29		2550	27500	1147	9.55	104.56	263160	10965	9.57	4.57	1049300	36.02	21.72	15.3660
12	24		18	6	12.63		528		54	218	209	1	222	141	377	600	29		2150	25000	1042	11.63	99.96	271980	11332	10.87	5.26.50	1092200	50.60	29.03	16.2780
13	24		24		12.38		529		54	216	208	1	222	140	353	600	21		1320	27500	1147	20.83	108.26	259340	10997	8.23	4.96.40	867100	65.67	37.52	16.7648
14	24			24	12.91		528		56	219	208	1½	222	145	375	600	33		2620	36000	1250	13.29	111.11	270080	11257	9.01	4.96.51	1113250	42.57	24.32	15.6930
15	24			24	13.27		586		56	218	208	1	222	140	371	600	29		2400	27500	1147	9.98	103.00	267680	11145	9.73	4.23	1080000	37.84	21.28	15.9480
16	24			24	13.99		505		58	216	208	1	222	135	363	600	36		2610	25000	1042	8.84	95.78	264720	10905	10.97	4.23.19	1126350	40.09	22.41	14.9070
17	24		12	12	12.50		595		66	218	209	1	222	141	357	600	39		2440	25000	1042	8.50	97.27	257040	10720	10.26	4.97.93	1206600	41.02	23.99	13.6490
18	24			24	11.21		495		63	219	210	1	222	130	365	600	23		2760	27500	1147	9.06	90.75	277200	11550	11.11	5.06.93	1170000	48.37	24.21	16.0200
19	24			24	13.56		590		61	219	211	1	222	129	395	600	21		1960	25000	1042	12.84	86.03	284500	11857	11.36	5.45.99	961.50	44.31	28.12	16.8450
20	24			24	12.96		513		59	218	210	1	222	125	376	600	19		1270	27500	1147	21.65	101.99	271960	11332	9.89	5.11.18	648530	53.89	30.78	20.3450
21	24			24	12.66		521		56	218	208	1	223	128	408	600	22		2570	27500	1147	12.86	91.17	263680	10820	10.32	5.10.38	1078950	46.96	25.98	17.9050
22	24			24	12.09		539		58	218	210	1	222	130	366	600	32		2600	27500	1147	10.57	104.56	263390	10972	9.58	5.01.28	1077100	41.19	23.45	15.6240
23	24			24	12.68		462		63	216	209	1½	221	130	305	600	41		2420	20000	833	8.26	91.52	219960	9165	10.99	4.09.84	1081150	44.69	25.59	17.1810
24	24				13.53		485		57	218	209	1	223	130	300	600	38		2760	20000	833	8.13	92.59	216000	9000	10.80	4.87.80	1096.50	47.82	27.32	16.6350
25	24			24	13.33		466		59	216	208	½	220	129	305	600	37		2460	20000	833	8.13	91.32	219120	9145	10.97	4.91.14	967.50	37.08	22.31	15.8730
26	24		12	12	12.42		509		62	218	208	1	222	129	336	600	27		2010	27500	1147	11.19	92.97	267260	11609	10.76	4.20.59	1149.00	46.93	27.66	19.5300
27	24		12	12	13.01		487		59	218	210	1	222	128	307	600	26		1200	20000	833	16.66	90.90	220640	9202	11.04	4.84.05	735.00	61.25	34.50	14.7340
28	24		12	12	12.55		503		47	219	210	1	222	129	340	600	25		2560	22500	937	8.79	91.83	245160	10215	10.91	4.53.76	1120.50	43.77	25.01	13.3110
TOTAL	672				165	507													61420	750000				7948.40				5082150			0.9.5.2.9.0
																				365 TONS											
																				26607											
AVERAGE	24				13.75	30.78	12.91		530		57	218	209		222	137.53		600	2894		2426	1393.T.	1086	1079	48.01	344005	11063	10.20	4.84.66	1072.19	44.19	26.25	15.8386

FIG. 6. MONTHLY RECORD OF PERFORMANCE

this kind can ever be considered perfect, the system which he has devised and which he uses at present, serves very satisfactorily. Three general records are kept, a daily, a monthly and an annual record. The daily record is, of course, the most important for the daily record is the basis of all other records. If the daily record is incomplete, the monthly and annual records will be incomplete.

The form used for the daily record is shown in Fig. 5. The top portion, as will be noted, contains all general data for the power plant as a whole. This record will show at a glance whether operating conditions are normal or not and if abnormal to what condition the abnormality is due. Below are four divisions, one for each boiler, which contain the necessary data for determining the steam output per pound of coal. Further down at the left is a table giving the totals on all boilers combined and at the right is a record showing the details and time of operating procedure. The daily record of water treatment is shown at the bottom.

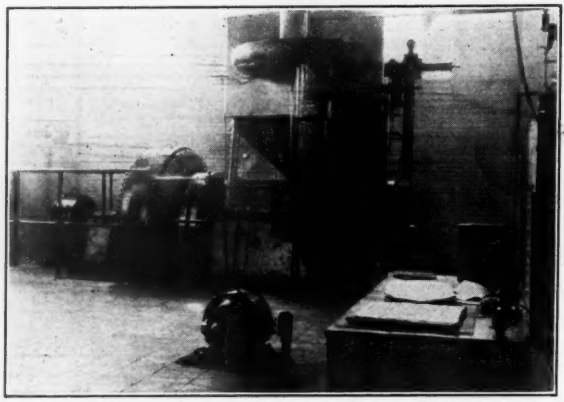


FIG. 7. THE 4-CYLINDER VERTICAL UNIFLOW ENGINE

Power Plant Performance Record

Initial Investigation Boiler No. 1 June 23, 1925

Plant of Onondaga Pottery Company
at Court St., Syracuse, N.Y.

CHIEF ENGINEER'S COPY

PLANT PERFORMANCE	Heat Balance based on coal as fired	
	Heat absorbed by boilers (Efficiency)	%
	Loss of heat up the stack	%
	Loss of heat in the refuse	%
	Loss due to moisture in coal	%
	Loss due to hydrogen in coal	%
	Radiation and unaccounted for losses	%
		100.00%
QUANTITIES AND COSTS	Water—Lbs. fed to boilers per day	lbs.
	Steam—Lbs. delivered per day	lbs.
	Fuel—Lbs. burned per day	lbs.
	Evaporation (actual) per lb. of coal	lbs.
	Cost of Coal per net ton delivered	$
	Cost of Fuel Oil per gal. delivered	c
	Cost of Steam per 1000 lbs.	c
	Boiler Horsepower—Average per hour	BHP
	Boiler Rating—Average developed	%
OPERATING CONDITIONS	Flue gas temp. °F; Feed water temp.	°F
	CO_2 %; Steam pressure lbs.; Superheat	°F
COAL QUALITY	Moisture % Sizing of Anthracite	
	Ash % No. 1 Buck %	
	Volatile % No. 2 Buck %	
	Sulphur %. No. 3 Buck %	
	B.T.U. as fired Dust %	
	Unburned carbon in refuse %	100.00%

Fuel Engineering Company of New York

By

FIG. 8. BOILER ROOM PERFORMANCE RECORD

This daily record is placed where everybody in the plant has access to it, and the firemen take not a little interest in it. No bonus is offered but the competitive spirit is keen and the men take considerable pride in maintaining top-notch efficiency.

Data from the daily record are transferred to the monthly record shown in Fig. 6 each day. This monthly record is an amplification of the general record shown at the top of the daily record sheet and contains all necessary figures for computing the total operating cost.

Besides the daily, monthly and annual records already referred to, there is also a Power Plant Performance Record. This is a daily record, kept by the Fuel Engineering Co. of New York, which shows all quantities and costs, operating conditions, quality of coal and plant performance. A copy of this form is shown in Fig. 8.

From the foregoing description of the plant and the methods of operation, it must be evident that the high efficiency obtained is due more to accurate knowledge of all conditions and intelligent management than to an unusual character of the equipment. The personnel is adequate but not unnecessarily large. It consists of two operating engineers and three firemen, besides the chief engineer. The men work six days a week on two 12-hr. shifts. The day shift always includes one extra fireman.

In concluding this article we acknowledge our indebtedness to the officers of the Onondaga Pottery Co. and to Harry Eklund, the chief engineer, for the privileges extended in gathering material used in its preparation.

IT IS SHOWN in the German magazine Waerme that instead of using the hot ventilating air from turbo-generators for warming rooms or re-cooling it for re-use, a greater saving can be effected by applying it to some drying process which operates all year, or by feeding it to the boiler furnace. The heat content of the ventilating air which leaves a 20,000-kw. turbo-generator is about 0.6 per cent of the heat supplied to the turbine. By feeding this air to the boiler furnace, a corresponding saving may be effected in the weight of the coal burned per kw-hr. produced. The weight of air required to ventilate the generator is only about 22 per cent of the weight of air required by the boilers.

IN A RECENT REPORT of the Department of Commerce on the Growth of Manufactures from 1899-1925, a tabulation of index numbers with the year 1919 as a base has been made for all industries. These numbers show that the physical volume of production has increased 178.4 per cent between 1899 and 1925, the number of persons engaged has increased 86.9 per cent, the primary horsepower employed has increased 256.1 per cent and the production per person engaged has increased 49 per cent.

Boiler Water Tests Should Be Utilized---I

PRACTICAL INTERPRETATION OF SIMPLE BOILER WATER TESTS IS NOT A DIFFICULT MATTER AND YIELDS A FUND OF INFORMATION. BY CHARLES E. JOOS*

TO THE AVERAGE engineer, water analyses and their interpretation at times are puzzling. In fact, many water analyses are so presented that their proper interpretation is not readily grasped by the engineer for whom the analyses are made.

The ways of reporting analyses are varied and sometimes the method used is such that it will not give the most information desired. The combination of the elements found by the analyst may be made differently as there is no accepted standard, hence with the same reported analyses different compositions may be given the water. It is because of this fact that engineers generally view water analyses with suspicion and frequently puzzle over them in attempting to get the information they desire.

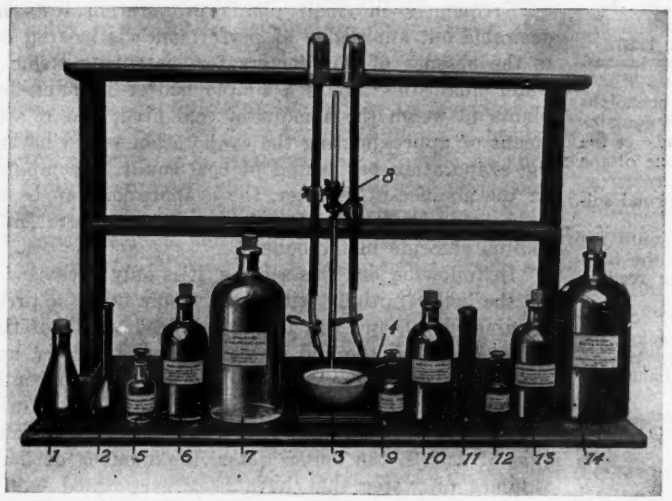
For boiler feed purposes, an analysis of different samples generally means to the engineer how much hardness the water contains for the purpose of estimating if possible the savings that may be due to the removal of hardness and prevention of scale. However, a water analysis is not so complicated as it seems and if the whole matter of analysis is stripped of the nonessentials and considered as a simple problem rather than a complicated one, a fund of information can be obtained by proper interpretation of the determinations made.

The value of a water analysis depends upon the interpretation that it receives and many times useless work is done in making an elaborate water analysis when a simple analysis is all that is necessary to determine the object in view. Frequently complete analyses are made where simple titrations will achieve the same result. Where water softening systems are in use certain daily tests are required so that the efficiency of the system may be maintained. These tests are simple titrations of alkalinity using the well known indicators, phenolphthalein and methyl orange. In addition to this, the water is tested for salt, chemically known as sodium chloride, using silver nitrate as the titrating agent and potassium chromate as an indicator.

METHODS OF CONDUCTING TESTS

For the benefit of those readers not already familiar with the simple titration tests a brief review of how these tests are made may be of value. Common titration tests are called, "The Alkalinity Test" and "The Salt Test." The purpose of the alkalinity test is to determine the alkalinity of the feed water or boiler water and distinguish the various chemicals that cause this alkalinity. The salt test is simply what it implies, namely, a means of determining the amount of sodium chloride in a water, or perhaps, chlorides of calcium and magnesium in a raw water. For our purpose in what follows, we can consider all the tests in terms of sodium chloride as it makes no difference if the chloride is in the form of sodium chloride, magnesium or calcium chloride. Tests for alkalinity are made in two steps. These are the determination of the "Ph." alkalinity (phenolphthalein) and the "M.O." alkalinity (methyl orange). The apparatus used to carry out these tests is pictured in Fig. 1 and consists of two burettes, a white porcelain dish, the necessary indicators, phenolphthalein (5 grams per liter of alcohol), methyl orange (1 gram per liter of distilled water) and potassium chromate (200 grams per liter of distilled water) and the titrating agents one-twentieth normal sulphuric acid and standard silver nitrate (5 grams per liter). These tests are covered in steps 1, 2, 3, 4, 5 and 6 of the detailed directions given.

Either of the readings, 4 and 6, multiplied by 1.5 will give the corresponding "Ph" or "M.O." alkalinities in grains per gallon expressed as sodium carbonate. The chloride or salt test may be made on the same sample



1. Sampling flask.
2. 100 cubic centimeter measuring flask.
3. Test cup.
4. Glass stirring rod.
5. Dropping bottle containing phenolphthalein (Ph) test solution.
6. Stock supply of phenolphthalein-solution.
7. Bottle standard N/20 sulphuric-acid for testing.
8. Burette with cap held in position by burette clamp and stand.
9. Dropping bottle with methyl-orange (M.O.) testing solution.
10. Bottle containing stock supply of methyl orange testing solution.
11. Graduate cylinder.
12. Dropping bottle containing potassium chromate solution.
13. Stock supply of potassium chromate solution.
14. Bottle with supply of silver-nitrate solution.

FIG. 1. APPARATUS FOR TESTING WATER IS COMPARATIVELY SIMPLE

*With the Cochrane Corp., Philadelphia, Pa. First part of an article dealing with the practical application and utilization of simple water tests.

that was used for the alkalinity tests and is covered by steps 7, 8 and 9.

In making titrations on a concentrated sample such as a boiler water, a good plan to follow to make a quick determination of the end point is to add four drops of titrating solution at a time when the test nears completion. This procedure will usually carry the test beyond the end point, making the change in color more distinct. To make a correction for this overrunning one-tenth c.c. is then subtracted from the reading. Four drops correspond to 0.2 c.c. so that a plus or minus error of 0.1 c.c. may be introduced under certain conditions, but this is within the limit of error for such determinations where the water is fairly high in alkalinity and salt such as a concentrated boiler water. For waters low in minerals, such as raw or treated water, a more accurate method is to add the titrating solution a drop at a time.

DETAILED DIRECTIONS FOR ALKALINITY AND SALT TESTS

1. Measure out 100 c.c. of water to be tested.
2. Pour into porcelain dish and add one drop of phenolphthalein indicator. This will turn the water red if it contains sodium carbonate (soda ash) or caustic soda or lime. If the indicator fails to turn red it is an indication that none of the above chemicals is in solution.
3. Fill up burette to zero mark with twentieth normal sulphuric acid.
4. Gradually add (titrate) the acid to the water until the red color starts to fade out. Continue adding until the faint pink color remaining entirely disappears. Take the reading and note this as the Ph. alkalinity.
5. To the same sample add two drops of methyl orange indicator and continue the titration with acid without filling the burette to the zero mark. In case the "Ph" reading was zero this test will start from zero. The indicator will change the water to a yellow color in the presence of any alkali.
6. Add acid until the yellow color just changes to an orange. This reading is the methyl orange or "M.O." alkalinity.
7. On the sample of water used for the "Ph" and "M.O." tests add 4 drops of potassium chromate indicator. This will turn the water yellow.
8. Fill the second burette to the zero mark with standard silver nitrate.
9. Add (titrate) silver nitrate slowly from the burette. Approaching the end point, a red color will appear and then disappear with each addition of silver nitrate. Continue the titration until this red color just stays permanent giving the sample a faint brownish red tinge. This is the end point and the c.c. of silver nitrate used represents grains per gallon of salt when the original water sample was 100 c.c.

If these tests are conducted and interpreted they will be of material benefit in the power plant when coupled with other operating data. Ordinarily we look upon these titrations simply from the standpoint of getting the best efficiency from the softener, insofar as scale prevention and priming is concerned. We do not realize, however, that these simple readings are capable of being interpreted to give us a fuller knowledge of operating conditions. It is with this purpose in mind that the writer feels that certain suggestions for the interpretation of these simple analyses may prove helpful to many operating engineers.

Determining Percentage Condensate Returned

Take, for instance, one of the most simple tests on the raw water, namely, that of the salt test. The salt content of a water in itself means but little, but if it is associated with other similar salt readings over other parts of the system then its real value becomes useful. As an illustration, suppose we have a plant which is using an unknown quantity of condensate but the amount of water evaporated is known if the feed water is titrated for salt, and we find it contains two grains per gallon and the combination of raw water and condensate shows a salt content of one grain, then we can assume rightfully that the mixture contains 50 per cent of raw water and 50 per cent of condensate, provided, of course, that the condensate is not contaminated as a result of priming. This interpretation is not confined to the mixture of raw water and condensate alone but can be interpreted to be a mixture of treated water and condensate in the event a softening system is in use. By knowing the total quantity of the water and the percentage of condensate, it is clear that the quantity of raw or treated water becomes a simple calculation.

Conducting Boiler Tests

Frequently in small plants evaporation tests are desirable but knowledge of performance is lacking due to the absence of flow meters for measuring steam or water quantities. It is a simple matter in hand-fired plants to weigh the amount of coal fired, and if some means of approximating the evaporation would be had, the evaporation per pound of coal could be computed. In the absence of a meter, the evaporation can be approximated by determining the rate of concentration of sodium chloride in the boiler.

In following out this scheme, it is only necessary to fill the boiler initially with fresh water up to a predetermined level, and run for any desired length of time as for 24 hr. at the end of which time the water level is brought up to the original level and the concentration of salt in the boiler water determined. By knowing the amount of salt in the feed water and the concentration of salt in the boiler water, the number of boiler volumes of water that have been evaporated can be computed by dividing the salt concentration of the boiler water by the salt concentration of the feed water. Knowing the volume of the boiler, the exact amount of water can be calculated.

In making such a test it must be remembered that the boiler should not be blown down during the interval of testing. Such an approximation does not take into account the quality of the steam, which is a factor that ordinarily can not be neglected since all the moisture leaving the boiler will carry with it a certain amount of solids depending upon the concentration. This carrying away of the solids makes it necessary to apply a correction to the actual salt concentration, for by our method of calculation this quantity would be low if the moisture correction is not applied.

TABLE I. DATA USED FOR MAKING APPROXIMATE BOILER TESTS

Salt in feed water	1 gr. per gal.
Salt in boiler water after test	30 gr. per gal.
Average moisture in steam	1.0 per cent
Volume of boiler	3000 gal.

To illustrate the foregoing, suppose we have the condition shown by Table I. To apply the correction due to moisture, we shall have to consider averages; therefore the average concentration of salt in the boiler

is (30 + 1) ÷ 2 = 15.5 grains. If all the steam were condensed, each gallon would contain 1 per cent of 15.5 grains or 0.155 gr. average. This means that every gallon of water leaving the boiler as steam would carry with it 0.155 gr. of salt, and since the salt content of the water entering the boiler is one grain per gallon, the salt remaining in the boiler would be 1.0 — 0.155 = 0.845 gr. for every gallon fed. Therefore the amount of water entering the boiler under the conditions above described would be (30 ÷ 0.845) × 3000 = 106,500 gal. Ninety-nine per cent of this would be steam and 1 per cent moisture, and from this point the efficiency of the boiler could be calculated.

It is, of course, evident that in such a test the accuracy is greater the longer the duration of the test, and shows in a simple way how an elementary salt test can be used as a flow meter in plants that are not equipped with mechanical flow devices.

Forged Drums Promote Safety at High Pressure

BOILER DRUMS FORGED WITHOUT SEAMS FROM A SINGLE INGOT GIVE STRENGTH OF WALLS EQUAL TO THAT OF METAL ITSELF, AND THERE IS NO LIMIT TO THE WALL THICKNESS, EXCEPT AS IMPOSED BY WEIGHT. BY JOHN L. COX*

WITHIN the last few years much attention has been paid to the failures of boiler drums in service, and many investigations made into their causes and prevention.

Records of the Hartford Steam Boiler Inspection & Insurance Co. show that of the boilers inspected each year about 2½ per cent have fractured plates or heads, defective riveting, or leaky seams, and a further proportion exhibit laminated plates. Of these defective boilers about 13 per cent are considered dangerous. Now that it is becoming customary to force boilers to a degree hitherto unprecedented, these figures may be expected to increase.

PROBLEMS OF DEFECTIVE RIVETED DRUMS

In November, 1926, Sub-Committee No. 6, on Embrittlement of Metals, of the Joint Research Committee on Boiler Feed Water studies, made a report in the course of which it stated that the embrittlement of boiler metal is an established fact and not a myth; that various investigations are by no means in accord concerning the basic cause or causes of the phenomenon but that there are certain points upon which there seems to be general agreement. They are: (a) Brittleness of boiler steel may occur in the presence of high concentration of caustic soda and result from straining the metal beyond the elastic limit, (b) Failures of this kind are intercrystalline in character, (c) The cracking of metal occurs in practically all cases along the line of the rivets and on the dry side of the plates.[1]

One widely held view requires the presence of caustic alkali in joints stressed beyond their elastic limit. Keeping the water in the boiler below a certain concentration of sodium hydroxide, not yet definitely settled, or calking the seams inside the boiler to prevent access of feed water there, and its concentration to a dangerous degree, should tend to prevent or entirely inhibit embrittlement.[2]

An extensive investigation of the phenomenon by a large boiler manufacturer showed, among other things, that cracks did not follow the line of maximum stress and that they all occurred in seams under tension having factors of safety, as normally calculated, from five to approximately ten.[3]

Another view is that the chemical action is essentially accelerating but that the cracking takes place even under conditions in which the possibility of chemical action is excluded, as intercrystalline fractures are found in boiler plates outside of the seams and in steam spaces above the water line of boilers.[4]

MANY CAUSES CONTRIBUTE TO INTERCRYSTALLINE FRACTURE

In an interesting paper recently delivered at a convention in Chicago it was shown that drifting of rivet holes, high pressures used in riveting, excessive calking, the extra thickness of metal in the seams which produces unequal expansion, and working of steel plates at a blue heat are all causes for intercrystalline fracture.[5]

One prominent German manufacturer has the following to say: "Permanent deformation and 'ageing' invariably set in after some time in the case of boilers constructed by the old method of riveting together plates that have been bent while cold. By 'ageing' is meant the property possessed by unalloyed mild steels of becoming brittle, if after having been stressed by tension or compression beyond their yield point, i.e., after having suffered deformation when cold, they are subsequently left in a state of rest for some length of time. The effect of ageing and recrystallization on non-alloyed steels reveals itself, as has been shown by numerous experiments made during the last few years by various investigators working independently of each other in various places, in an extraordinarily low impact resistance and sometimes also a low yield point, whereas an elongation test gives no indication of any deterioration."

Although these various views are not in full harmony as to facts, nor the reasons why boiler drums fail, all lead to one conclusion—that a drum made without seams and without any cold working of the metal offers the maximum of security.

Economies to be derived from the use of higher pressures in steam turbines have demanded suitable boilers for their production, increasing the difficulties of an unsatisfactory situation. With increasing pressures the steel plates have become, first, too thick to be handled by the old equipment and, finally, too thick to be worked at all by bending and riveting. Few shops are equipped or have the necessary technique to handle plates as thick as 2¼ in. Beyond about that point recourse must be had to other modes of construction.

*Asst. to the President, The Midvale Co., Philadelphia, Pa.

[1] Mechanical Engineering, Vol. 48, No. 11a, p. 1368.

[2] Parr and Straub on Embrittlement of Boiler Plate. Proceedings A. S. T. M. Vol. 26, Part II, p. 77.

[3] Mechanical Engineering, Vol. 48, No. IIA, p 1370.

[4] Applebaum, Proceedings A. S. T. M., Vol. 26, Part II, pp. 82, 83.

[5] Kriegsheim Minutes of the National Board of Boiler and Pressure Vessel Inspectors, Chicago Convention, May 25, 1926.

Two courses are open, either to bend hot and weld plates too thick for cold bending and riveting, or to forge the drums from a solid block without a weld. The former method is applicable to plates of medium thickness and is permitted by the A. S. M. E. Boiler Code[6] if the weld be made by the forging process, the strength of the weld being taken at 35,000 lb. per sq. in. with plates having a range in tensile strength of 45,000 to 55,000 lb. Autogenous welding may be used only where the safety of the structure is not dependent upon the strength of the weld.[6]

cold, or it is heated, separated from its sinkhead, upset, and punched or trephined, under a powerful forging press while hot.

This hollow billet is then heated and expanded between a mandrel supported at both ends and a top die parallel to it as in Fig. 2. As the diameter of the forging is unconfined, while the wall thickness is reduced by forging, the hole is enlarged until it is several inches larger than the diameter of the largest mandrel on which the piece is subsequently to be drawn.

Then the expanded billet is reheated, the dies

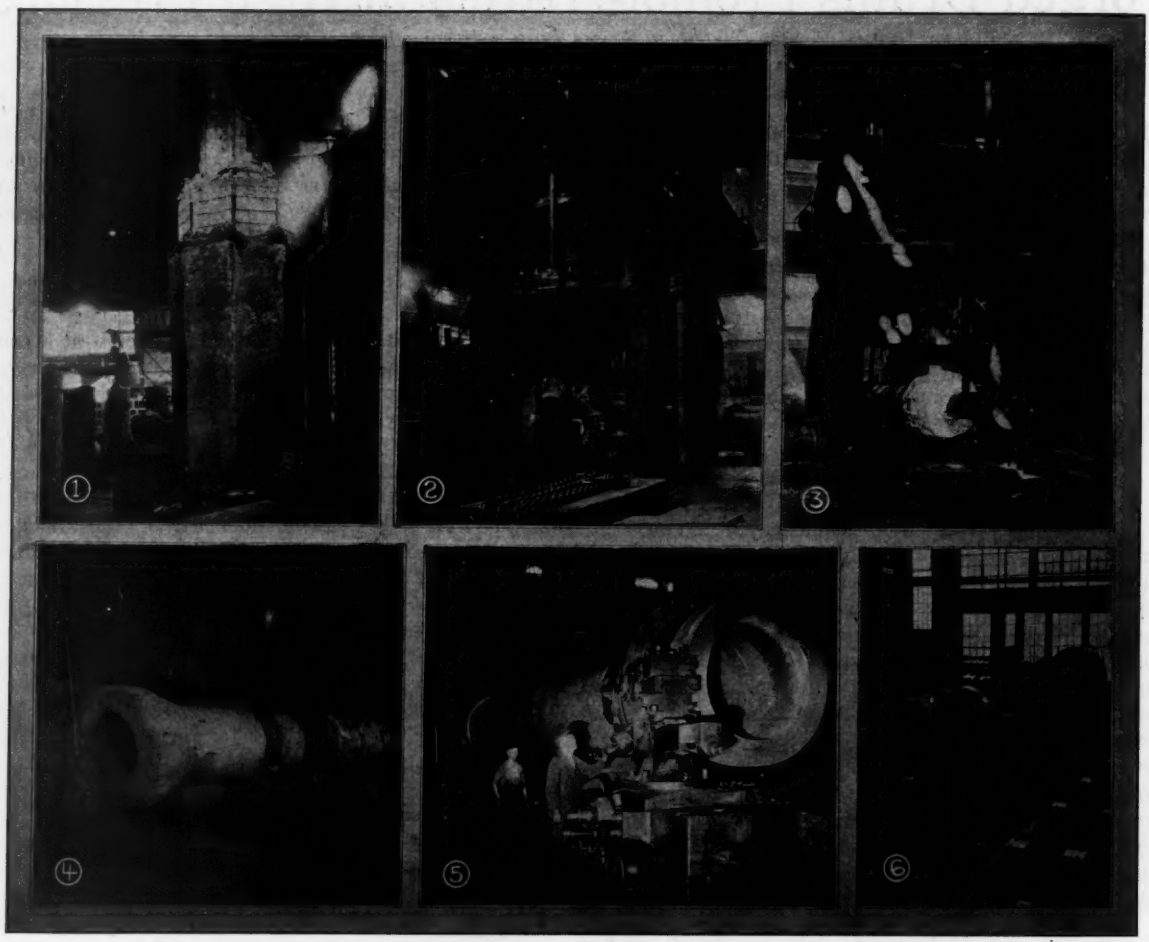


FIG. 1. AN 82-IN., 270,000-LB. OCTAGON INGOT. FIG. 2. EXPANDING A DRUM UNDER 9000-T. PRESS. FIG. 3. DRAWING A DRUM ON THE MANDREL. FIG. 4. PARTIALLY FORGED 162,000-LB. DRUM ON WAY TO THE ANNEALING SHOP. FIG. 5. PREPARING A DRUM FOR CLOSING-IN THE ENDS. FIG. 6. CLOSED-IN DRUM BEFORE OPENING THE THROAT

The second method is the one here specially to be considered. The strength of the walls is that of the metal itself, as there is no weld, and there is no limit to the wall thickness except that imposed by considerations of weight.

An ingot similar to Fig. 1 is cast of open hearth steel meeting the required chemical specifications and of weight sufficient to produce the forging required after making due allowance for scrap and for heating losses.

This ingot is cooled, bored and decapitated while

changed to a lower V die and an upper forging die of the same width. A tapered mandrel, smaller in diameter than the hole in the billet, is then inserted and forging begun on part of the billet's length in the manner illustrated in Fig. 3. Under these conditions both the external and internal diameters of the forging are reduced, the scale in the bore due to heating cracking and falling off. The mandrel is withdrawn and the scale removed, for, if allowed to remain, it would make pockets in the bore of the forging, as well as tend to key the mandrel fast.

[6] A. S. M. E. Boiler Construction Code, 1924, p. 14.

After the scale has been removed, the mandrel is reinserted and forging begun in earnest with heavy pressures. The metal, confined between the three die faces and the mandrel, elongates as the external diameter is reduced, forging being continued until the metal cools below a working heat. In this manner, step by step, the billet is roughed out, until it is of a diameter from which it will be possible to bring to final forged sizes, in one heat, several feet of the middle length of the drum, using a mandrel somewhat smaller than the final internal diameter of the drum, to allow for machine boring. Each end is then forged as was the center, the mandrel being from time to time backed out a little, to prevent its sticking.

Ends of the forging as in Fig. 4 are generally left somewhat full in diameter to provide extra metal for closing in to make the heads, if they are to be integral, of a thickness exceeding that which would naturally be produced by the upsetting action of the closing in operation.

Forging of the body being finished, the drum, annealed at a temperature above the critical range to refine the grain and remove stresses, is cooled slowly in the furnace and is then tested for physical properties.

According to the tentative boiler code, one longitudinal tension test specimen is taken from each end midway of the wall thickness and a transverse bending specimen from that end of the forging which was uppermost in the ingot.

After acceptance for physical properties, the drum is bored to finished diameter and the enlarged ends, if present, contoured in a lathe to give the desired distribution of metal in the heads after closing-in. Closing-in is done under the press in special dies and the drum then appears as in Fig. 6 which was taken just before opening the throat.

A usual proportion for the thickness of the head at the manhole is 1½ times the thickness of the parallel wall of the drum, to which thickness the head tapers at the knuckle. By proper provision of metal before closing in and by skillful use of appropriate dies, it is possible to produce almost any shape or thickness, within reason, that may be desired in the head.

Specifications for Seamless Steel Drum Forgings

1. Process. The steel shall be made by either or both the following processes: open hearth or electric furnace.
2. Discard. Sufficient discard shall be made from the top and bottom of each ingot to secure soundness in the portion used for the drum forging.
3. Forgings. The forgings shall be made from solid cast ingots punched, bored or hot trephined. The walls of the hollowed ingot shall be reduced in thickness at least one-half by forging on mandrels.
4. Chemical composition. The steel shall conform to the following requirements as to chemical composition:

	Class 1	Class 2
Carbon, max., per cent	0.35	0.45
Manganese, per cent	0.30	0.65
Phosphorus, max., per cent acid	0.04	
Phosphorus, max., per cent basic	0.035	
Sulphur, max., per cent	0.04	

5. Ladle analyses. An analysis of each melt of steel shall be made by the manufacturer to determine the percentage of the elements specified. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified.
6. Check analyses. The purchaser may make an analysis from a broken tension-test specimen representing each drum forging. The chemical composition thus determined shall conform to the requirements specified.
7. Heat treatment. Prior to taking test specimens, the whole of the forging shall be simultaneously annealed, above its critical temperature. If additional forging is required after taking test specimens, the whole of the forging shall again be simultaneously reannealed above its critical temperature but not above the temperature of the first anneal.
8. Tension tests. The forging shall conform to the following requirements as to tensile properties:

	Class 1	Class 2
Tensile strength, min. lb. per sq. in.	60,000	75,000
Yield point, min. lb. per sq. in., tens. str.	0.5	0.5
Elongation in 2 in. min. per cent	26	24
Reduction of area, min. per cent	42	38

9. Bend tests. The test specimen shall withstand being bent cold through 180 deg. around a pin 1 in. in diameter, without cracking on the outside of the bent portion.
10. Test specimen. a. Tension and bent-test specimens shall be taken from a full size prolongation of each forging after annealing, as specified.
b. One tension-test specimen shall be taken from each end of each forging. The axis of the specimen shall be located midway between the inner and outer surfaces of the wall parallel to the axis of the forging, the two specimens being taken from diagonal corners of an axial plane. Tension-test specimens shall conform to dimensions established as standard. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.
c. One bent-test specimen shall be taken from the end of the forging corresponding to the top of the ingot. The axis of the specimen shall be in a diametral plane perpendicular to the axis of the forging. The bend-test specimen shall be 1 in. by ½ in. in section with edges rounded to $\frac{1}{16}$ in. radius.
11. Number of tests. a. Two tension tests and one bend test shall be made from each forging.
b. If any test shows defective machining or develops flaws, it may be discarded and another specimen substituted.
c. If the percentage of elongation of any test specimen is less than that specified and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribed scratches marked on the specimen before testing, a retest shall be allowed.
12. Retests. If the results of the physical tests of any forging do not conform to the requirements specified, the manufacturer may reanneal the forging and retest shall be made as specified.
13. Permissible variation. The thickness of the parallel wall of each forging shall not be less than that specified. If the thickness of a portion of the wall of the forging is less than that specified due to accidental or unavoidable irregularity of bore, the forging may be accepted by the purchaser, provided such irregularity will not require lowering of the allowable working pressure below that for which the drum is designed. The overweights are considered a matter of contract between the manufacturer and the purchaser.
14. Finish. The forging shall be free from injurious defects and shall have a workmanlike finish.
15. Marking. Each forging shall be legibly stamped by the manufacturer at each end with the name of the manufacturer, manufacturer's test identification number and the minimum tensile strength for the class of forging specified. The manufacturer's test identification number shall be legibly stamped on each test specimen.

Test Specimens Sometimes Taken Before, Sometimes After the Forging Has Been Completed

In certain cases it is possible to take the test specimens after all forging has been finished, as in Fig. 6, but, in case the shape of the finished ends will not permit this, the tests are taken before the closing in of the ends. After this hot-working step, the whole forging is re-annealed again above the critical range

but below the temperature of the first annealing. This insures that there shall be no disturbance of the physical properties established by that annealing.

As a circular manhole is much cheaper to make than an elliptical one, a growing use of this shape is noticeable. If there is no nozzle of a diameter sufficient to admit the manhole cover after the ends have been closed in, it is necessary to fasten the finished covers inside the drum before closing the second end and to protect them from injury during the subsequent forging, annealing and machining operations upon the drum.

Finally annealed, the drum is taken to the machine shops where it is turned on the exterior, the manholes cut and their cover seats finished, the covers fitted, any

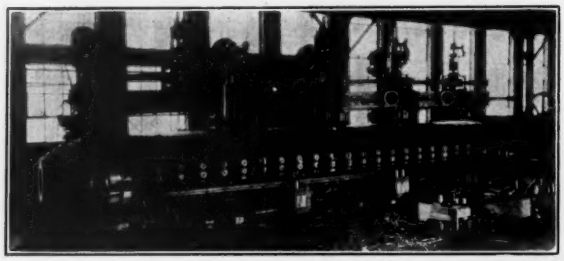


FIG. 7. TUBE HOLES ARE CAREFULLY LAID OUT AND DRILLED

fittings desired are attached and blanked off and the drum subjected to hydrostatic test. After the hydrostatic test, tube holes are laid out and cut, Fig. 7, the drum is given another inspection and, if found acceptable, is shipped.

As the forged steel drum is a comparatively new product, no general specifications for its manufacture have as yet been adopted by the American Society of Mechanical Engineers but the specifications given have been approved by the Council and will be generally distributed in the near future.

Stress Formulas for Riveted Drums Not Applicable

It is evident that the strength of the walls of the seamless forged steel drum is uniform throughout. As this type of drum is especially used with high steam pressures and consequently thick walls, the usual formula for the hoop stress in a thin cylinder, $S = Pd \div (D - d)$, is not applicable. Conditions are better expressed by Clavarinos' formula, $S = (P \div 3)\ [(r^2 + 4R^2) \div (r^2 - R^2)]$, S being the stress per sq. in., P the internal pressure in pounds per sq. in., d the internal diameter and D the external diameter, r and R are respectively the inner and outer radii of the drum, all expressed in inches. Of course the steam pressure that can be carried is limited by the strength of the tube hole ligaments.

Attachment of Fittings

Fittings may be attached to the thinner drums of weldless steel by rivets in the usual manner but the flanges of high-pressure fittings are often too thick to permit satisfactory riveting and must be attached by steel bolts. Fittings with saddle flanges must have the bearing surfaces of flange and drum carefully fitted and bedded, or the calking will be ineffective. To put the radial studs in shear, and add to the longitudinal strength of the drum, where cut away, the strength of the metal in the fittings flange, the reamed holes in the flange are used as guides for drilling very shallow holes of the same diameter in the drum wall. The drill is then removed, a bushing inserted in the flange hole and the hole for the thread drilled part way through the drum wall. After tapping, special tight-fitting studs are inserted which are plain cylinders where they cross the joint between drum and fitting, thus acting like rivets in shear.

To permit such drilling in position, it may be necessary to use fittings with separable coupling flanges screwed on, instead of being cast in one piece with the rest of the fitting, a form of construction usual with the extra heavy forged fittings now coming on the market.

Another construction is to use fittings with plain instead of saddle flanges for attachment to the drum, having a short extension on the drum side of the flange. This is turned, faced and shouldered for a copper gasket, a seat for the gasket being cut in the surface

FIG. 8. A COMPLETED DRUM JUST BEFORE PREPARING FOR SHIPMENT

of the drum. Assembly is by parallel instead of by radial, studs.

None of these studs are in shear, consequently adding little to the longitudinal strength of the drum, but in very thick drums this may be a matter of no importance.

Variations in Design

The 1200-lb. pressure boiler for the Weymouth station of the Edison Electric Illuminating Co. of Boston, which has attracted much attention, has a seamless forged cross drum 56½ in. outside diameter, 48 in. inside diameter by 34 ft. long with 12 by 16-in elliptical manholes. It was made from a 262,000-lb., 78-in. octagon ingot and weighed 162,000 lb. as forged. A similar drum of different design, for 1400-lb. working pressure for the same station, is shown in Fig. 7 on the drill presses. It is 57¼ in. outside diameter, 48 in. inside diameter by 38 ft. 4 in. long, weighs 108,000 lb. finished and has 15-in. circular manholes.

In the endeavor to avoid every possible cause of trouble, a recently introduced type of steam generator has the four cross drums all made as seamless forgings with integral heads. The front top drum is 48 in. inside diameter and the other three are 31½ in. inside diameter, all with wall thicknesses depending upon the pressure to be carried. Figure 8 shows the lower rear drum with fittings attached.

Use of Power in Industrial Plants*

MODERNIZATION OF PLANTS, CHANGES DUE TO ELECTRIC DRIVE AND CONSIDERATIONS ON BOILER FURNACE DESIGN

MODERNIZATION of the industrial power plant was the subject discussed by C. G. Spencer who emphasized the importance of industrial power by showing that in 1923 the report of the Bureau of Mines indicated that 31 per cent of the bituminous coal used in the United States was in industrial plants, 30 per cent used by railroads and 7 per cent by public utilities, the balance being for domestic use, gas plants and for shipping. Of stationary water-tube boilers manufactured annually, about 25 per cent, on the square foot basis, goes to utility plants and the remaining 75 per cent is used, for the most part, by industrial plants.

Industrial power plants are classified into three headings: Those which generate all their own power; those which partly generate and partly purchase; and those which purchase all power. For the plant which both generates and purchases it is desirable to have reverse power, overload or low voltage relays which will open the line switch in case of overload but, in addition to this, to prevent generators from being overloaded and the generator circuits broken, a practical method is to have an auxiliary switch on the main circuit breaker of the incoming power line which trips out certain predetermined parts of the load when the circuit breaker of the incoming line opens. In most industries it is feasible to segregate certain circuits or motors which can be tripped for short periods without serious interference with the work of the plant.

Mr. Spencer called attention to the need for good engineering when planning the location and arrangement of the control room for handling incoming purchased power, to shorten feeders and keep the control plant away from fumes and dust, which will avoid shutting down to clean insulators and other parts of the control station.

POWER FACTOR AND ECONOMY

Another thing which should be given careful attention is the power factors on the various feeder lines. It is often overlooked that losses are about twice as great when operating at 70 per cent power factor as when operating at 100 per cent but it is fairly common to find plants operating at or below 70 per cent. It is well worth while to have a survey of the plant to determine the power factor on various lines, as this often discloses underloaded induction motors and conditions of overloading which can be avoided by shifting of the load on various motors without additional investment. Use of synchronous motors is also often justified and the synchronous motor as now installed can be started with no more complications than the induction motor. The static condenser has also been developed to the point where it can be considered a useful and reliable piece of power equipment.

Outdoor substations have been widely adopted in central station practice and can be used to advantage in industrial plants, the generator leads being taken into the yard where the generator switches, as well as step-up and step-down transformers and feeder switches are all located in the open, thus effecting a big saving in building and taking care of the dissipation of copper fumes in case of trouble.

HEAT ECONOMIES

For industries which have excessive low pressure steam in summer and shortage during the heating season, the mixed-pressure turbine offers a solution. Bleeder turbines are used for taking off both process and heating steam, also for feed water heating. Where bled steam is replacing an existing system, study of the heat balance should be made, as often electric auxiliaries will be found effective, in place of the existing steam-driven units. Other points which may well be adapted from central station practice are the efficient air pump for modern high vacuum and the generator air-cooling system with closed circuit, which removes heat by means of the condensate and keeps the generator windings free of dust and dirt.

While the use of waste heat and the economy in generation are important, the tendency to adopt innovations to produce high thermal efficiency without figuring out the cost, including overhead, of a kilowatt-hour or a thousand pounds of steam should not be neglected. The true measure of the effectiveness of a plant is the annual cost per unit of product including fixed charges and operating expense.

OVERLOADING BOILERS

In selecting boilers for industrial plants, there is a tendency towards larger units and fewer of them. This reduces first cost of boilers, piping and structures and often permits the using of a structure, built to house a larger number of small boilers, simply by raising the roof of the building. While we hear of boilers operating at 400 and 600 or even higher per cent of rating, engineers designing industrial boiler plants should avoid under-boilering and adopt moderate operation. Where too few boilers are installed, the troubles are cumulative and the severe strain incidental to excessively high operation usually results in a high percentage of boiler outage and probable slighting of the maintenance.

While Mr. Spencer considered generalization on this point dangerous, he believed a conservative rule was to design so that one boiler could be out for external and internal cleaning and repairs without loading the remaining boilers beyond 300 per cent of rating. This would mean that in a plant with two boilers normal operation would be at 150 per cent of rating, for three boilers would be 200 per cent, for four boilers 225 per cent and so on. These figures are based on well-designed refractory-lined furnaces but, for water-cooled furnaces, higher ratings may be safely reached.

Furnace volume and heat release largely determine boiler performance and with early ignition by intimate mixture of fuel and air and use of preheated air, furnace volume may be made more effective. Three or four years ago the heat release was in the order of 23,000 B.t.u. per cubic foot per hour. Now, because of

*From papers presented before the Regional Meeting of the A. S. M. E. at Erie, Pa.

the use of preheated air and introduction of turbulence in entering fuel and air mixture, this has been increased to 40,000 with some examples of 60,000 when using water-cooled furnace walls.

Character of the ash has an important bearing on the design of walls, as a low fusing ash high in iron and sulphur will wash down and destroy fire brick similar to the action of hot water on a lump of sugar. When such fuel is used, air cooling of the walls or the use of water-cooled walls is of help but the decision to install partial or complete water cooling must depend on the characteristics of the fuel and on the expenditure which is justified. Attention should be given to flame travel also, in order to avoid direct impingement of the flame on the walls, which will produce erosion and serious slagging of boiler tubes.

Decision as between pulverized fuel and stokers requires careful study. Stoker design and performance have been improved greatly in the last few years and there is a trend toward the use of the unit system of pulverized fuel for both small and large installations. Fear of ash nuisance which has sometimes been adverse to pulverized fuel may be disregarded, as it is found to be negligible or equipment has been developed to collect the ash. Explosion danger cannot be ignored, but designs have been developed to guard against this and to minimize the effect of explosion should one occur. For ash disposal either from stokers or powdered coal there is a trend toward the use of sluices, discharging the ashes into a sump whence they are removed by a clam-shell bucket.

Use of Flue Gas Heat

High pressures and temperatures can be utilized to advantage, any low pressure heat being available by means of the bleeder process. Where superheat is used, radiant heat superheaters should be considered either alone or in series with the convection type. Where there is a great amount of high temperature gas escaping, waste heat boilers are often justified, unless a very low power rate is available, but there is usually a problem in the removal of abrasive dust from the gases and induced draft equipment should be selected which is not subject to rapid wear.

Speaking generally, the economizer field is in plants where low-head heat or steam bled from a turbine is not available to heat feed water, while the field for air preheaters is where the heat from the exit gases cannot be used in feed-water heating but can be used for heating combustion air. Experience has shown that preheated air is of value for both stoker and pulverized fuel installations. Use of cast iron tubes or of steel tubes protected by cast iron or by lead coating inside and outside has reduced the upkeep in economizer plants. Corrosion from dissolved oxygen in the feed water is now controlled by deaerating the boiler feed before sending it to the economizer.

Modern use of large boiler units operating at high percentages of rating makes it essential to maintain clean surfaces on the inside of tubes and drums, not only to obtain high efficiency but also to prevent tube failure and lengthen the intervals between shut-downs for cleaning. Today it is imperative to remove hard-scale-forming solids from the feed water before it enters the boiler and in many cases it is economical to evaporate make-up water.

Hold Load Constant

For plants where waste heat boilers supply the greater part of the power, it is desirable to have an outlet for excess steam, which frequently, an evaporator will provide. Deficiencies in steam are usually taken care of by a separately-fired auxiliary boiler. For such a plant it is advantageous to have a contract agreement to deliver surplus power from the waste heat boiler to the power company and in return that the power company shall supply power during times of steam deficiency. Another method of evening up the load on the boilers is the use of a steam accumulator which has been found advantageous in many industrial plants, especially abroad.

Introduction of automatic control, which acts with little delay and great precision, has resulted in substantial saving but such control should not be installed unless the management is prepared to employ high grade attendants to supervise its operation. This is true of all instruments and automatic equipment. A plant, to be modern, must be equipped with sufficient instruments to indicate and record what is going on but such records are of no value unless they are intelligently studied.

Operate Boilers Conservatively

In the discussion on Mr. Spencer's paper, the fact was emphasized that industrial plants cannot as a rule employ as expensive engineering talent as can central stations but this can be overcome to a certain extent by having the services of a competent supervising engineer engaged by a number of plants in co-operation. Another point was that, when applying the results of central station practice to industrial plants, account must be taken of the particular conditions at the industrial plants, as central stations are always designed for the conditions of their particular locality and account is taken of the fuel and the labor situation where the plant is to be operated.

W. A. Shoudy emphasized the importance of reliability of operation and spare equipment to insure against shut-down. Another point was simplicity because of the employment in the industrial plant as a rule of men of less experience than those in the central station. Attention was also called to the fact that, in the industrial plant which utilizes process steam, make-up water is usually from 10 to 20 per cent of the boiler feed and care must be taken to provide this amount of make-up of good quality. If bad water is all that is available, then the make-up must be treated and care must be taken to keep scale-forming material out of the boilers, particularly if water-cooled furnace walls are used. When increasing the percentage of rating at which the boiler is operated, the gases in the chimney are also increased in temperature and this tends to cut down boiler efficiency. Often it is better to use more boilers and operate those in service at high efficiency than to provide economizers and air heaters. It is important that no boiler should ever be operated at a very low rating and the number of boilers should be such that, under extreme low-load conditions, such boilers as are in use will be operating effectively.

On the question of selling power to central stations and purchasing central station power during peak load, it was pointed out that the central station peak may come at the same time as the peak load of the industrial plant but it can often be arranged so that these peaks are staggered and then the exchange can be made to good advantage. Usually, the load factor in an industrial plant is much higher than that in a central station. H. W. Brooks mentioned one case where there was an average of over 90 per cent load factor on the basis of a 15 min. peak, which he had never seen obtained in central station operation. He also spoke of a plant where the operation was on the basis of 600 per cent rating and sometimes as high as 800 per cent, the installation costing about $75 a kw. As to the heat release, he gave this as 17,500 for refractory covered walls, 20,000 for water-screen walls, and 25,000 for complete water-walled furnaces. He felt that at the present time, going higher than this in industrial plants was not justifiable. Tests at the Philadelphia Navy Yard have been carried out, on the Scotch-marine type boiler, with heat releases as high as 80,000 B.t.u. per cubic foot per hour and loss of unburned combustible not over 2 per cent, so that this may become practicable in time.

So far as the percentage of power cost to the total cost of products is concerned, it was pointed out that the increasing use of power is notable and, while this means that the machinery takes more power as it becomes more nearly automatic, less power is required per worker.

Effects of Electric Drive

Summarizing the effect of electric drive on industrial plants, R. H. Rogers stated that between 65 and 70 per cent of all power used in American industries is electric and the newer plants are practically 100 per cent electrified. Some of the effects of so large a use of electrification are the retirement of industrial plants to large centers and the tying in with a power system of small water powers previously used separately. Also the water power development on a stream will be combined into fewer heads and the owners of these powers will form a hydro-electric generating company from which they will receive the power needed. These changes result in the concentration of industries into larger communities where the life of employes will be more comfortable and labor turnover will be reduced. The space occupied by the power plant is rendered available for active production work and more rapid and economical production is possible.

Another result is conservation of natural resources, both by utilizing small water powers tied together into a large system and also by the reduction in the fuel consumption in steam plants. Production is speeded up because more power is available for each worker and machinery can be operated at a higher speed when using electrical drive than was possible in many cases with mechanical drive. Arc welding and electric heating have also made possible changes in methods of production which have resulted in economy.

All these things have naturally reduced production cost, notable examples being the use of electric power shovels in place of steam shovels for mining, operation of mine hoists by electric motor, oil well drilling and pumping by electric power, the driving of steel mill machinery by electric motors and the operation of paper mills for both large capacity and high speed by means of electric drive.

Boiler Furnace Design

W. J. Wohlenberg and F. W. Brooks presented a paper dealing with the influence of furnace water walls on the furnace volume requirement, dealing especially with the influence of the extent of water wall surface exposed to furnace radiation on the heat absorption efficiency of the steam generator; its influence on the permissible rates of energy release for a limited furnace temperature; its influence on the permissible range of load variation for given high and low limits of furnace temperature; and the influence of refractory coating on the furnace water walls for the conditions above outlined.

Refractory Vs. Water-Cooled Walls

In general, for coal having low-fusing ash, the rate of energy released from the furnace must be reduced because reasonable increase in the excess air will not hold the furnace temperature below the ash fusing point. In the discussion of the furnace, two types were considered, one having the top space cold, that is the boiler tubes exposed at the top of the furnace, and the other having all faces cold, that is all sides of the furnace having water-cooled walls. Between these there is the furnace having the top and bottom cooled and the one having the top, bottom and two sides cooled, but the limiting effects will be for the furnace having only the top cooled and for the one having all six sides water-cooled. As a result of observation, the conclusion was reached that a considerable extension of the water wall area in furnace envelopes above that representing the best fraction of surface cooled, generally results in an increase of the total volume requirements for a given final escaping gas temperature. Also, when water-cooled furnace walls enclose a considerable part of the furnace, they permit of an increase in the rate of energy released for a given furnace temperature and this increase is such that the average rate of heat absorption per square foot of total heat surface is considerably greater than it would be at a lower rate of energy release. Studying the effects of water-cooled walls, it is noticed that if, for example, the fraction of the surface that is cooled be increased from 0.2 up to 1, the permissible rate of energy release for a given flame temperature is more than doubled and it is concluded that the furnace designer should proportion the furnace walls for his combustion conditions, including the proper amount of cold surface.

The author stated that, even at the same excess air for both cases, a stoker-fired furnace of symmetry corresponding to that of the pulverized coal furnace would undoubtedly show a lower temperature of the refractory walls for equivalent energy release rates.

Limit of Load Variations

Study of the conditions brought out that, when two furnaces, one with some refractory wall area and the other with entire area water-cooled, are proportioned for the same total energy release in B.t.u. per hour at a given maximum flame temperature, the average flame temperature falls off more rapidly with decrease in load in that furnace whose walls are entirely water-cooled.

Obviously there is a low limit below which the furnace temperature should not go in order to maintain satisfactory combustion conditions and this will mean that, for the entire water-cooled furnace, the permissible range of load variation is less than for the refractory furnace. It will be possible to operate economically at a lower mean flame temperature in the furnace with refractory wall area than in one surrounded only by bare water walls but, for large steam generating plants, high maximum capacity is often of greater importance than wide permissible range of load variation. For the entire water-cooled furnace, highly preheated air is desirable, but its use raises the flame temperature and thereby decreases the allowable maximum capacity for a given ash fusion point.

Refractory Lining Desirable

Because of these conditions it seems to have been found advantageous to use a refractory coated water wall in place of the bare water wall and various types of refractory coating were discussed. The effect of a gap between the refractory coating and the water-cooled tubes was mentioned but it was stated that, unless the conductivity of the refractory is quite high and the gaps over 0.05 in. a single gap will have only small influence on the interior refractory temperature for walls one inch or more in thickness. Conductivity of the usual refractory may be taken as 10 B.t.u. per sq. ft. per degree difference of temperature per inch of thickness but carborundum has much higher conductivity and its rate may be taken as 50 B.t.u. Average temperature of the refractory increases rapidly with thickness of the refractory and, for a wall having 6 in. of refractory thickness, the furnace conditions are about the same as if there were no water wall back of it.

Air Heating

Study of the effect of preheating air shows that the temperature both of the furnace and the refractory will be increased more rapidly with preheated air as the rate of energy release increases, than it will with natural air and, of course, will be higher at all rates of release. For instance, with a one-inch refractory, the furnace temperature will be increased from 2000 deg. at a 10,000 B.t.u. energy release rate, up to 2300 deg. at a 20,000 B.t.u. release rate, air being at 70 deg. F. If the air temperature is 500 deg., the corresponding values are 2100 deg. for a 10,000 B.t.u. release rate and 2450 deg. for a 20,000 B.t.u. release rate. Comparison of the temperatures for a 20 per cent and 40 per cent excess air supply shows that the influence of variation of excess air is quite small.

Comparison of characteristics shows that mean temperature of a refractory-front water wall is about 1000 deg. for loads even as low as 25 per cent of maximum, while for a completely water-cooled furnace, the temperatures will be between 300 and 500 deg. at 25 per cent of maximum load. This means that the refractory lined, water-cooled wall will have much lower losses due to incomplete combustion, particularly at lower rates of energy release.

Conclusions of the authors are that the completely water-cooled furnace envelope permits the highest possible rates of energy release so far as flame temperature is the limiting factor; that refractory-lined water walls may give energy release rates approaching that of the entirely water-cooled wall with bare surfaces. That, for similar furnaces where refractory walls are not cooled, greater volume will be required for a limiting mean flame temperature. If bare water-cooled walls are introduced as part of the furnace envelope, in order to increase the allowable energy release rate to that of the refractory-lined, water wall furnace, the remaining refractory wall is likely to cover only a small part of the total furnace surface and combustion conditions at lower ranges of load may be deficient, particularly if the refractory portions are not properly located.

Need of further experimental research in the field of radiation and heat transfer was emphasized because, while such analyses as were made show the comparative effect of water-cooling with bare walls and with refractory lined walls, the whole series of values may be shifted up or down with the knowledge of better data from experiments as to the question of heat transfer and flame temperature.

Steam Demands Control Engine Operation

New Method of Governing Steam Engines Enables Cutoff to Be Controlled Either by the Electrical Load or by Demands for Process Steam as Conditions Demand. By C. H. S. Tupholme

BACK PRESSURE steam engines are being used extensively in European plants where heat is required both for process operation and for power production. The suitability of this type of engine as a prime mover is due to its high overall efficiency within wide load ranges and under varying conditions of entering and exhaust steam and to its adaptability to changing requirements of service.

Of particular interest are those engines, which, unlike ordinary prime movers, are not governed according to power requirements, but adjust the cutoff to the demand for heating and process steam. This method of operation is possible wherever the steam engine is either mechanically or electrically coupled in parallel with other sources of power which automatically adjust their contribution to the total load, or when the machines driven off this supply system are capable of consuming any excess in output which the steam engine can offer by being fitted with suitable speed governors.

Such an engine is shown diagrammatically in Fig. 1. The live steam from the boiler passes through pipe K to engine cylinder C, in which it expands down to the pressure existing in low pressure main H.

To adapt the engine output to the requirements of process steam in a factory, it is necessary that the steam in pipe H react on the governor in such a way that the pressure remains constant. This is achieved by varying the cutoff in the cylinder to suit by means of what may be termed a modified speed adjusting device T of the speed governor G. The apparatus effecting this is shown at E in Fig. 1. Provision must be made to enable this method of regulation to be cut out and to

reinstate the usual speed control to suit power requirements.

It may sometimes happen that the demand for process steam in the plant is in excess of what the engine can give with the prevailing load, or that steam is also required when the engine is out of service or has to be stopped temporarily for some reason or other. In such cases, the bypass reducing valve Z comes into operation, admitting sufficient make-up steam from pipe K into pipe H to keep the pressure constant. Further, a large spring loaded safety valve S, inserted in the main H, blows off as soon as more process steam than can be utilized in the plant, is released by the engine, due to a heavy load. This valve can also be operated by hand for exhausting to the atmosphere and when starting or stopping the engine this must always be done.

Figure 2 shows the arrangement of the layshaft with eccentrics, speed adjusting device, governor, etc., pertaining to back pressure, or to ordinary non-condensing engines which are only governed for constant speed, where the output adapts itself to the power requirements. The sheaves of eccentrics A (cutoff eccentrics) which operate the steam inlet valves, ride on eccentric bushings B (main eccentrics) keyed to the shaft and controlled by the shaft-governor R, which on initiation of a regulating process alters their relative position. In this mechanism an oil pressure operated servomotor C,

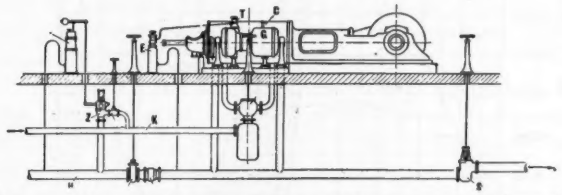


FIG. 1. ARRANGEMENT OF STEAM PIPING IN A BACK PRESSURE ENGINE PLANT IS SIMPLE

rotating with the layshaft is inserted to transmit the movement of the governor flyweights to the cutoff eccentrics, thus forming part of the speed adjusting device.

Balanced Oil Pressure in Two Systems Control Operation

This cylinder is sub-divided into four chambers by a wing piston E keyed on to the shaft and two internal bosses D extending to the hub of the wing piston, as shown in the small section. Each two, diametrically opposite chambers are interconnected by oil passages F_1 and F_2, forming two distinct oil systems. The oil pressure in the chambers connected to passage F_1 is kept constant by the spring loaded relief valve G revolving with the layshaft, whereas passages F_2 connecting the other two chambers lead through a stationary connection H to a spring loaded overflow valve I fitted to the governor lagging.

Both oil systems are fed with oil from the forced lubricating pump through a central port in the layshaft and radial drillings L and K. Normally, the springs of the two valves G and I are so adjusted that the oil pressure in all four chambers of the cylinder is equal, the device then merely acts as an oil brake or buffer to any displacements of the governor. By turning the handwheel N, the tension on spring O is changed and the equilibrium of the oil pressure in the two systems upset. This causes the cutoff eccentrics A to turn, forcing them to take up a new position, corresponding to an altered cutoff and output. If the engine is coupled in parallel with other sources of energy, the latter have to deal with the excess or deficiency of this extra power. The device is so designed that any increase of oil pressure under valve disc I causes a reduction of the cutoff.

The arrangement shown in Fig. 2 is intended for back-pressure engines which have only to be governed to run at a constant speed, i. e., their output varies according to the amount of power required in the plant. If on the other hand, the output of the engine has to be adjusted in accordance with the quantity of steam required in the plant, the oil pressure under valve I is controlled by the pressure in the process main through the insertion of a transmitter shown at E in Fig. 1. The valve is in this case fitted with a 3-way cock, which

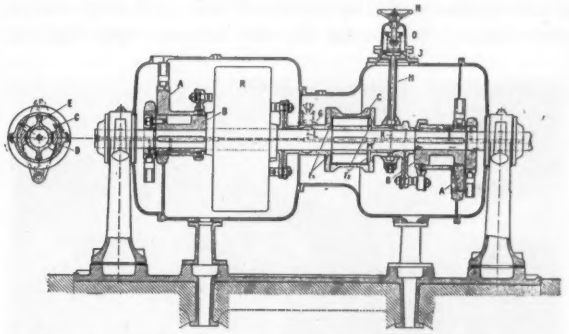


FIG. 2. OIL PRESSURE IS UTILIZED FOR THE OPERATION AND CONTROL OF THIS ENGINE GOVERNOR

enables the engine either to maintain constant speed or constant back pressure in the process steam main in which case the function of valve I is cut out.

Pressure is transmitted by a cylindrical cast-iron vessel with a carefully ground-in piston and spring-loaded pilot valve. A small pipe from the process steam main in which the pressure is to be kept constant is connected to this vessel, which is fitted in the lower part with water and in the upper with oil. The annular space of the pilot valve is connected through a pipe with the casing of the overflow valve and through the 3-way cock and tube H with cylinder C. The pressure oil entering this closed system flows to the annular chamber from whence it is released through the guiding edges of the pilot valve into the oil return. The pressure in the chamber is always such as to maintain equilibrium between the power exerted by the steam pressure from underneath the piston against the force of the spring combined with the oil pressure on the ring area of the pilot valve.

Following the law of stability of shaft governors, a certain definite oil pressure in the speed-adjusting device corresponds to a certain definite cutoff and, consequently, also to an equally defined back pressure. The sensibility of the steam pressure regulation is considerably enhanced by eliminating the friction of rest, by subjecting all movable parts to a slight pulsating motion. These pulsations are induced by a pulsator inserted in the inter-connecting pipe between transmitter and overflow valve, consisting of a small ram, pushing to and fro, into the oil columns, the pulsating motion being derived from an eccentric on the layshaft.

Application of Diesel Power to Rapid Fluctuating Loads

PRESENTATION OF ADVANTAGES OF DIESEL ENGINES OVER MOTORS AS MOTIVE POWER FOR BALING COMPRESSES. BY LLOYD YOST*

IN A PAPER on Recent Developments in the Design and Application of Diesel Engines, read at the Oil Power Week meeting of the Chicago Section of the A. S. M. E. April 21, 1927, Mr. Yost brought out the special adaptability of the Diesel engine in an installation such as shown in Fig. 1.

In most instances, Mr. Yost said, baling compresses had been driven by electric motors. This method of powering had proven very expensive because the maximum load was of relatively short duration, but, at the same time, long enough to require a very heavy motor. In accordance with the usual methods of fixing electric power rates, the annual charges became very high in

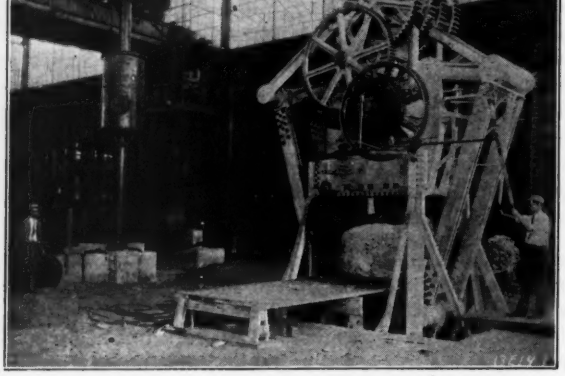


FIG. 1. INSTALLATION OF BALING COMPRESS DRIVEN BY A DIESEL OIL ENGINE

proportion to the current actually used, particularly as work of this kind is largely seasonal. An analysis was therefore made of the possibility of the Diesel engine drive.

Extreme fluctuation of energy experienced during a cycle of operations of the compress is shown in terms of torque on the engine shaft in Fig. 2. The torque changes on a motor shaft under the same conditions of load would be the same or rather the torque times the speed would be the same in both cases. The mean torque of the cycle was found to be only 1600 ft. lb. although the maximum torque was 6000 ft. lb. The problem was to design a flywheel that, in conjunction with the range of speed permitted, namely the amount of permissible slowing-down, would carry the job over the peaks at the necessary frequency of the baling operation, which in this case was three times per minute.

There is, of course, a peculiar condition in a Diesel engine, namely that it is desirable to carry a stop on the fuel injection so that the quantity injected per cycle will not be more than can be actually burned. More than that produces extremely bad combustion, causing a direct loss of fuel and interfering with the efficiency of operation of the engine.

This cotton compress installation is, of course, a relatively simple one but the same principle applies to many other forms of driven machinery, some of which have a great variety and complication of operations, such as those occurring in dredges and excavating machinery in which there are a number of motions, which may or may not be required at the same time.

This brings us to the consideration that, in the application of Diesel engines to industrial equipment, the direct question is not so much one of rated horsepower,

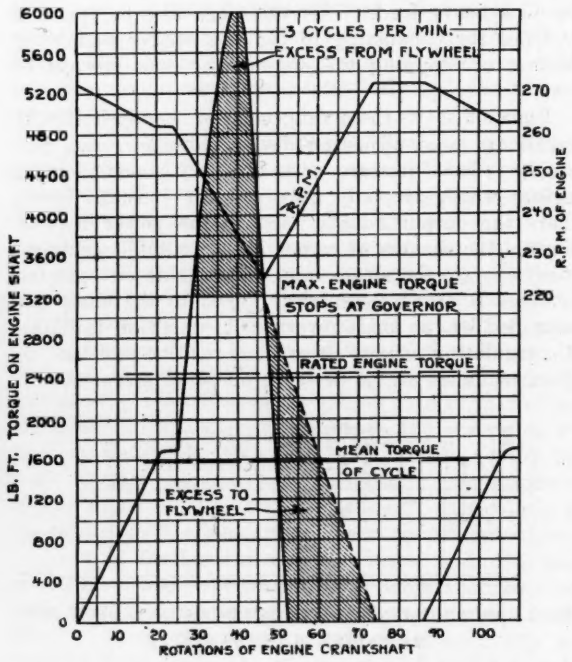


FIG. 2. TORQUE CURVE OF AN "ECONOMY BALER" COTTON COMPRESS, DRIVEN BY A 120-B.HP. FAIRBANKS, MORSE & CO., DIESEL OIL ENGINE

as one of the application of the engine itself, the maximum torque that is available from the engine and the period over which this torque can be sustained, together with the recovery factor which depends, to a large extent, upon the governor itself and the principle of injection, as well as the whole combustion system.

IF A FUSE is too large it will defeat its avowed purpose by refusing to "blow" at the proper time, while a fuse too small will go so quickly as to render the motor incapable of doing its work. Fuse sizes are measured by the amperes they will carry continuously without melting. A line carrying 25 amp. should not be fused at over 25 amp. Within certain limits, of course, the ampere rating is independent of voltage, so that a 5-amp. fuse will carry the same amount of current on a 110-v. line as it will on a 220-v. line but no more. On high voltage lines, however, the fuses are made longer to minimize the danger of arcing when they burn out. Unless a fuse is of the indicating type, which leaves a small black spot on the side when "blown," every fuse should be tested before putting it into service.

*Manager, Research Division, Fairbanks, Morse & Co., Chicago.

Lubrication of Diesel Cylinder Important

OXIDATION OF LUBRICATING OIL IS AN IMPORTANT ITEM TO BE CONSIDERED, BUT MUCH OF THE TROUBLES LAID TO LUBRICATING OILS ARE THE RESULT OF DIRTY FUEL OIL OR DIRTY AIR

REGARDLESS of what base lubricating oil may be made from or what care of methods used by the refineries in refining these oils, oxidation takes place after reaching a certain temperature. If an improper method is used for applying the lubricating oil to the power cylinder, the oxidation of the oil is greatly increased, and undesirable products form in the oil before it reaches the piston.

Proper methods of applying this oil or getting it to the inner cylinder surfaces, were covered by W. O. Northcut at the recent Regional Meeting at the A. S. M. E. in Kansas City. Under normal conditions with properly designed cylinder liners and piston rings properly lubricated an engine should give between 750 and 1000 hr. operation per 0.001 in. of cylinder liner wear. With proper application of oil to the pistons this may be increased to from 1800 to 2000 hr. per 0.001 in. of cylinder wear at the maximum cylinder diameter. The arrangement of the lubricating oil piping, the lubricating oil injection tubes, the size of the oil ports in the cylinder lining and the design of the mechanical lubricator are details to be considered.

Large oil ports in the cylinder liner, air pockets in the lubricating oil line and oil grooves in the piston skirts are details which assist in the oxidation of the oil. More attention should be paid to the condition of the oil film rather than to the quantity. The finding of the cylinder walls well covered with an oil film is often misleading, for it is a very complicated problem to discover what condition this oil film may be in, due to the fact that being improperly applied, it is likely that the oil contains oxidizing elements.

OXIDATION OF OIL INCREASES WITH LENGTH OF SERVICE

Original specifications of four oils are given in Table I. The condition of oil No. 2 after a one year's run in an engine is given in Table II. Tables III and IV tell the conditions of oil No. 1 after the engine has been cleaned out and run two weeks and four weeks respectively. Table V shows the analysis of sediment from the four samples of oil taken from the branch feed lines after the lines have been cleaned and the engine running 48 hr.

These analyses give the conditions of the oil to which they are converted before entering the cylinder. The figures show conclusively an increasing degree of oxidation with the number of hours, as the engine was run under similar operating conditions for each test. These detrimental conditions could be overcome by a little attention being paid to the design of the lubricating system on the engine. The pistons of a two-cycle engine can be lubricated above the exhaust ports successfully by using a properly designed lubricating oil injection tube. To lubricate a two-cycle engine below the exhaust ports the oil ports in the cylinder liner, when oil ports are used, should be very small and should be arranged to come under the center of the bridge.

Special designs of lubricating oil injection tubes are of assistance in improving cylinder lubrication. One design which is in use consists of a plug with a single spiral groove. The tube should register the oil between the first and second piston ring from the top when the piston is on the bottom. The function of the spiral groove is to offer a resistance to the flow of oil to balance the impulse of the gas pressure. New oil is prevented from oxidizing as the gases cannot reach it and the new uncontaminated oil reaches the inner portion of the cylinder liner where piston rings can pick it up and spread it in a film on the inner cylinder wall.

Temperatures and proper cooling systems have considerable effect on the wear of the metal because they change both the quantity and quality of the oil reaching the cylinder wall. Grit in the oil, ash in the fuel and dust brought in with the air are external influences

TABLES I-V. ANALYSIS OF VARIOUS OILS BEFORE AND AFTER USING SHOWS INCREASE IN OXIDATION WITH SERVICE

Table No. 1

	Flash °F.	Fire °F.	Vis. 100°F Saybolt Univ.	Vis. 210°F Saybolt Univ.
Oil No. 1	410	460	410 Sec.	50 Sec.
Oil No. 2	410	470	398 Sec.	55 Sec.
Oil No. 3	425	490	556 Sec.	65 Sec.
Oil No. 4	455	520	1,030 Sec.	86 Sec.

Table No. 2

Vis. Saybolt Univ. 100°F.		480 Sec.
Water		1.38%
Total sediment		1.78%
Analysis of total sediment—		
Asphaltic matter	0.72%	
Carbonaceous matter	0.94%	
Ash	0.11%	1.78%

Table No. 3

Flash, deg. F.		405
Fire, deg. F.		465
Vis. Saybolt Univ. 100°F.		466 Sec.
Vis. Saybolt Univ. 210°F.		60
Acidity No.		0.226
Total sediment		0.42%
Analyses of total sediment—		
Asphaltic matter	.140%	
Carbonaceous matter	.218%	
Ash	.062%	
Ash	.062%	0.42%

Table No. 4

Flash, deg. F.		410
Fire, deg. F.		470
Vis. Saybolt Univ. 100°F.		482
Vis. Saybolt Univ. 210°F.		62
Acidity No.		.0560
Total sediment		0.74%
Analysis of total sediment—		
Asphaltic matter	.360%	
Carbonaceous matter	.305	
Ash	.075	0.74%

Table No. 5

Sample of Oil No. 1—Total Sediment,	0.135%
Analysis of sediment:	
Asphaltic matter	.034%
Carbonaceous matter	.080%
Ash	.021%
Sample of Oil No. 2—Total Sediment,	0.348%
Analysis of sediment:	
Asphaltic matter	.049%
Carbonaceous matter	.164%
Ash	.034%
Sample of Oil No. 3—Total Sediment,	0.154%
Analysis of sediment:	
Asphaltic matter	.056%
Carbonaceous matter	.084%
Ash	.016%
Sample of Oil No. 4—Total Sediment,	0.218%
Analysis of sediment:	
Asphaltic matter	.073%
Carbonaceous matter	.123%
Ash	.060%

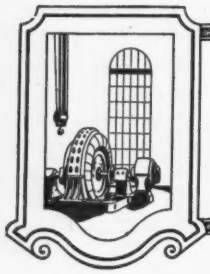
which must be considered and which can be eliminated with proper equipment.

The question of mean effective pressure is also important as it is this factor which determines the rating of the engine on the amount of fuel that has to be burned in that particular cylinder. Combustion results in a certain amount of heat, a large portion of which must be taken care of by the cooling system of the engine. Some systems are better than others due to design features but often engines of the same design will show differences in operation because of the kind of water that is being circulated and its tendency to form scale.

New Bayside Station Aids Wisconsin Hydro Plants

ON PAGE 600 of the above article, which appeared in the June 1, 1927, issue, the list of equipment mentions a magnetic drum at the head of the apron flight conveyor. This magnetic drum should have been credited to Magnetic Mfg. Co., Milwaukee, Wis. It was incorrectly listed with the conveyors supplied by another company.

THE VIEW from the top is worth less than the climb.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Determining Short Circuit Currents*

THE CALCULATION OF THE PROBABLE MAGNITUDE OF SHORT CIRCUIT CURRENTS BY USE OF PERCENTAGE REACTANCE. BY W. F. SUTHERLAND

SHORT-CIRCUIT currents on power systems of any appreciable size are limited in their magnitude by the reactance of the various types of apparatus through which they flow—the generator, the transmission line,

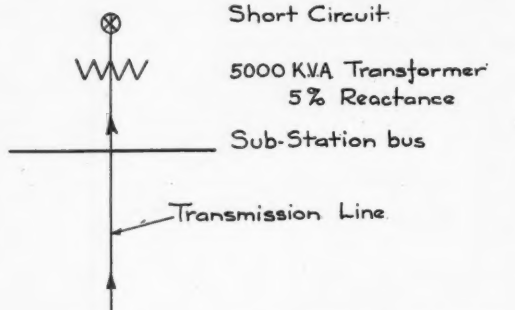


FIG. 1. ELEMENTARY DIAGRAM OF GENERATING STATION, TRANSMISSION LINE AND SUBSTATION

the transformer and the reactor all contribute their quota of reactance.

Reactance can be considered in a number of ways. Like resistance, it impedes the flow of current and of course like it can also be expressed in ohms. A voltage is built up across a reactance of any sort when current flows through it, much as is the case with a resistance. This counter-electro-motive-force, always acting against applied voltage, can be measured or computed in volts, and these at some chosen load current, usually that at full load can be expressed as a percentage of the applied voltage.

For instance a single-phase transformer with its secondary short-circuited requires a certain applied voltage to circulate full load current through its windings. Readings are taken of volts, amperes and watts, the resistance determined and by means of the old familiar impedance triangle the reactance in ohms is readily obtained. This multiplied by the value of current flowing gives the reactance voltage. This when expressed as a percentage of rated voltage gives the per cent reactance as it is called.

Or reactance might be expressed as kv.a. A resistance with current flowing through it dissipates a certain amount of energy and it then can be rated in terms of watts or kilowatts, as is customary when speaking of domestic and industrial heaters. Something similar can be done with reactance, only since no power is absorbed, beyond that necessary to take care of resistance losses, reactance is rated in terms of kv.a.

Take a typical example, a single-phase current-limiting reactor rated at 76 kv.a. 100 amp. per phase, 762 reactive volts per phase. The full load value of current is obviously 100 amperes, the voltage drop given is 762 v. and of course the rating follows as 76 kv.a. If we desired to express the value of this reactance in terms of a percentage, one thing more would be required, the voltage of the circuit on which it is to be used. Let us assume for the moment that this is 13,200 v. and that three reactances will be used on a three phase circuit. At rated current, each reactance will produce a voltage drop to neutral of 762 v. and since line to neutral voltage on the 13,200-v. circuit is $\frac{13{,}200}{\sqrt{3}}$ or 7600 v., each reactance will be rated at $\frac{760}{7600} \times 100$, or 10 per cent.

Further, an interesting fact also comes to light. The energy transmitted by the three lines of a three-phase transmission line at 13,200 v. and 100 amp. is 2290 kv.a., giving a 10 per cent value again for the reactor since $2290 \div 3 \div 10 = 76$ kv.a., the rating as above given.

While it is comparatively easy to obtain the reactance value of any piece of equipment in percentage of its full load capacity, the various units comprising a complete system will have varying capacities and in consequence before any calculation can be made as to the magnitude of a short circuit, these reactances have to be reduced to one common base.

As an example, take the system shown diagrammatically in Fig. 1. The effect of line reactance will be neglected for a moment. We will assume 1000 kv.a. as a convenient base from which to start. The sub-station

*This is the second of a series of three articles on the engineering problems due to short circuit currents on power systems. The first appeared on p. 681 of the June 15 issue and a third will appear in a subsequent number.

transformer having a reactance of 5 per cent based on 5000 kv.a. will have an equivalent reactance at the 1000 kv.a. base of:

$$5 \times \frac{1000}{5000} = 1 \text{ per cent.}$$

The generating station transformer will likewise have a reactance of:

$$5 \times \frac{1000}{10{,}000} = 0.5 \text{ per cent.}$$

And the generator reactance likewise reduces to a value of:

$$15 \times \frac{1000}{20{,}000} = 0.75 \text{ per cent.}$$

Adding these together, we obtain a total reactance of 2.25 per cent.

Nothing remains now but to find the short-circuit kv.a. as follows: divide the assumed value of 1000 kv.a. by 2.25 and multiply by 100. This results in a figure of 44,400 kv.a., which will be the power fed into a short-circuit at the point indicated. The amperes involved are readily calculated by the usual formulas.

Other methods are available for the calculating of short-circuit currents but in general they are somewhat more cumbersome and are not so readily applied. The expressing of reactance in terms of a percentage of full-load power at one stroke eliminates all consideration of voltage and voltage-current transformations.

In the above example line reactance has been neglected. It is, however, always estimated in accurate work where the lines are of any appreciable length and are of the overhead type. Having obtained the absolute value of reactance in ohms by calculation or from transmission line tables, the percentage reactance is easily calculated by means of the following formula:

$$\text{Per cent reactance} = \frac{100\ I^2\ X}{\text{Kv.a.}}$$

Where X = reactance in ohms of one line to neutral
I = normal full load current.

Kv.a. = Kv.a. transmitted over one line i.e. equal to amperes per phase multiplied by line voltage to neutral.

The percentage so obtained holds good for either one line or three, since for three lines the reactance trebles as does also the kv.a. transmitted. Conversion to a common base for calculation is made on the basis of the three-phase energy transmitted.

In the application of these principles to station design, fairly complicated and tedious calculations result at times. The various possible switching arrangements all have to be taken into consideration and each point where a short-circuit may occur must also be allowed for. Calculating tables, on which the various possible combinations in a net-work, can be set up, are available and these eliminate numerical calculation to a large extent.

It is a comparatively easy matter, however, to run through a simple problem, deriving therefrom valuable information as to the relative magnitudes of short-circuit values under differing conditions. A single line diagram in skeleton form of the system is first prepared as in Fig. 2. This shows all the incoming feeders, transformer banks, busses, and one or two out-going feeders in a typical station. From this a schematic circuit diagram, Fig. 3, is prepared. This, by means of the various horizontal lines, shows the various possible bus combinations. Reactance values are placed opposite each piece of reactive equipment, these being reduced to some common base, in this case 5000 kv.a.

It will be noticed that since we have a bus tie in the center of both high and low tension busses, two high

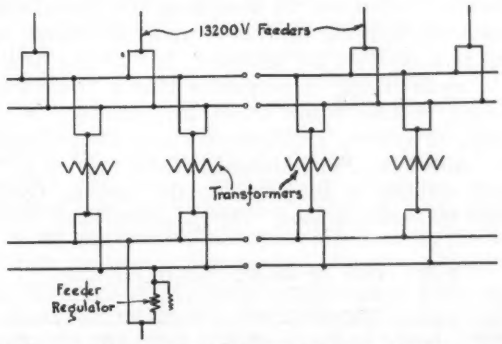


FIG. 2. TYPICAL SUBSTATION DIAGRAM SHOWING FEEDERS, BUSSES AND TRANSFORMERS

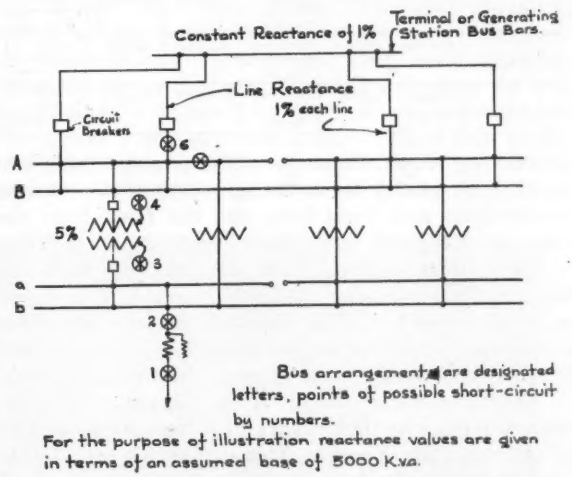


FIG. 3. SCHEMATIC DIAGRAM SHOWING POSSIBLE CIRCUIT COMBINATIONS IN SUBSTATION

tension switching arrangements are possible, and two low tension, giving a total of four possible combinations which can be designated by the various combinations of the letters placed opposite each bus circuit shown thus, —Aa, Bb, Ab and Ba.

Suppose for the moment that we take combination Aa, that is, the station is divided into two complete units. One half the station only then need be considered. The generating station has a fixed and constant minimum reactance which does not vary with the switching arrangement adopted in the substation. This has been assumed as 1 per cent, for the purposes of illustration. The two incoming feeders onto either section of substation high-tension bus have a reactance value in parallel of $1 \div 2 = 0.5$ per cent, while the two transformer banks on each section likewise have a

reactance of 2½ per cent in parallel. The total reactance to a fault on the low-tension windings of a transformer, low-tension bus or out-going feeder will be the sum of these values or 4 per cent.

To emphasize the fact that any value of kv.a. can be used as a base, it has been chosen in this case as 5000 kv.a. The short-circuit kv.a. will then be $\frac{5000}{4} \times 100 =$ 125,000 kv.a. The points where this value is obtained are marked 1, 2 and 3 on the diagram.

Usually a short on the secondary of a transformer is considered as being equivalent under the worst conditions to a short on the secondary bus and in passing it is a useful thing to remember that a transformer secondary breaker where banks are paralleled is not subjected to as great a current flow as a feeder breaker off the same bus. For instance, a feeder breaker in the present example is subjected to the current flowing through two transformers. On the other hand, if the transformer should break down, the primary feeds into the fault as usual, whereas the secondary power reverses its direction and feeds back into the fault from the other transformer.

TABULATION OF SHORT CIRCUIT RESULTS

Bus	Location of Short Circuit + Voltages Obtained.					
Arrangement	1	2	3	4	5	6
Aa.	125000 K.V.A.	125,000	125000 total 62,500 thru' Trans Sec Brkr.	333,000	333,000	166,500 Thru feeder breaker 333,000 total.
Bb	200,000 K.V.A.	200,000	200,000 total 150,000 thru' Sec Brkr.	400,000	400,000	100,000 thru feeder breaker 400,000 total
Ab	200,000 K.V.A.	200,000	200,000 total 150,000 thru' Sec Brkr.	343 000	343,000	157,200 thru feeder breaker.
Ba	133,000	133,000	133,000 total 66,500 thru' Sec Brkr.	400,000	400,000	100000 Thru feeder breaker.

Thus, in this example, there is a two to one ratio and the transformer breaker need only be one-half as strong as a feeder breaker. This advantage rapidly diminishes as the number of banks paralleled increases and both breakers are usually made of equal rupturing capacity.

Short-circuits anywhere on the primary bus, high-tension feeders or the primary of a transformer are all of one value which can be estimated as follows. In the present case, with bus-tie open only two feeders will feed into a fault and the reactance in series from generator to fault will be of the value 1½ per cent, giving as a result the value of 333,000 kv.a. It should be noticed that only one-half of this value flows through any one feeder breaker to a bus-short or to a short on one of the feeders, so the duty imposed on a feeder breaker is not so great as it is on a transformer primary breaker. This difference again diminishes as the number of feeders alive increases.

It will be readily apparent that the class of service on which a breaker is installed bears no relation to the performance required of it and more than likely, a breaker on a feeder supplying a small transformer house may be required to interrupt a much larger current than the breakers in a substation of much greater capacity.

The first step in calculating short-circuit conditions in a substation has been worked out in more or less detail for one bus arrangement; the other possible variations also admit of calculations and when completed, the results are tabulated so that the worst conditions may be estimated and provision made accordingly.

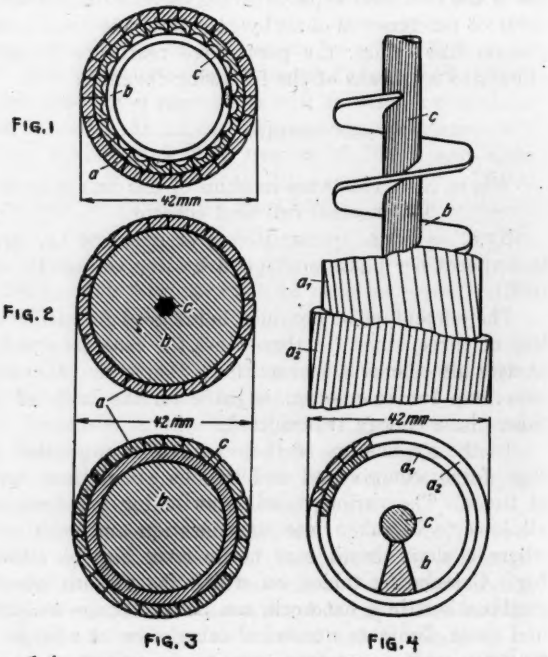
The table gives the complete results obtained from an analysis of the hypothetical station just considered. A number of useful deductions can be made, for instance, certain portions of the high tension equipment carry only one-half; two-thirds or three-quarters of the total current depending on the fault. Others such as transformer primary feeds are liable to carry the total short-circuit current.

The striking manner in which short-circuit currents are reduced in magnitude through the splitting up of a station into two or more parts is forcibly shown.

Note that the circuits Ab, that is with high tension bus open and low tension bus closed, lead to large inequalities in current flow through the lines and apparatus, for short-circuit on the high tension side of the transformers. Two paths are open, one through the left-hand feeders to the short circuit directly, the other, through the right-hand feeders to the right-hand transformers, to low tension bus and thence through the left-hand transformers to the short circuit. Only 28,600 kv.a. flows this way, due to the relatively high impedance of the path. The two left-hand feeders carry most of the load.

German Hollow Transmission Cables

HOLLOW transmission cables for electric power lines are becoming more popular in Germany. One utility company in western Germany uses a 220,000-v.



FIGS. 1-4. SECTIONS OF HIGH TENSION CABLES USED IN GERMANY

hollow cable of 42 mm. (1.65 in.) diameter and 400 mm.² (0.62 sq. in.) cross section, copper being the working metal. Figure 1 shows a cable made by the Felten-

Guilleaume-Carlswerk A.-G. A is the conductor which is also utilized mechanically, b is a round wire spiral spring which in place of the formerly used metal tube envelops the carrying wire c. Figure 2 shows a cable made by the Siemens-Schuckert-Werke in which b is a filler of insulating material which carries the conductor a. The carrying cable c may be in the center of the cable as in Fig. 2 or placed around the insulating material as in Fig. 3. The hollow cable made by the A.-E.-G. or German General Electric Co., shown in Fig. 4, has one or two conductors a_1 and a_2. Around the carrying cable c is constructed a reinforcing spiral which does not carry current.

Steel cable is of late not used for the carrying cable, but instead a less resistive hard copper of 40 kg. per mm.^{2} or bronze of 70 kg. per mm.^{2}, which are both stronger. A special steel alloy is, however, used for hollow aluminum cable, which requires special protection against atmospheric influences. The hollow cable is 25 and 42 mm. (0.98 and 1.65 in.) in diameter. The copper cross sections are from 120 to 185 mm.^{2} (0.186 to 0.287 sq. in.) at 25 mm. (0.98 in.) diameter and as much as 400 mm.^{2} (0.62 sq. in.) at 42 mm. (1.65 in.) diameter. Hollow cable of pure aluminum has also been built, having a maximum cross-sectional area of 690 mm.^{2} (0.944 sq. in.) at 42 mm. (1.65 in.) diameter.

Automatic Substation Serves Office Building

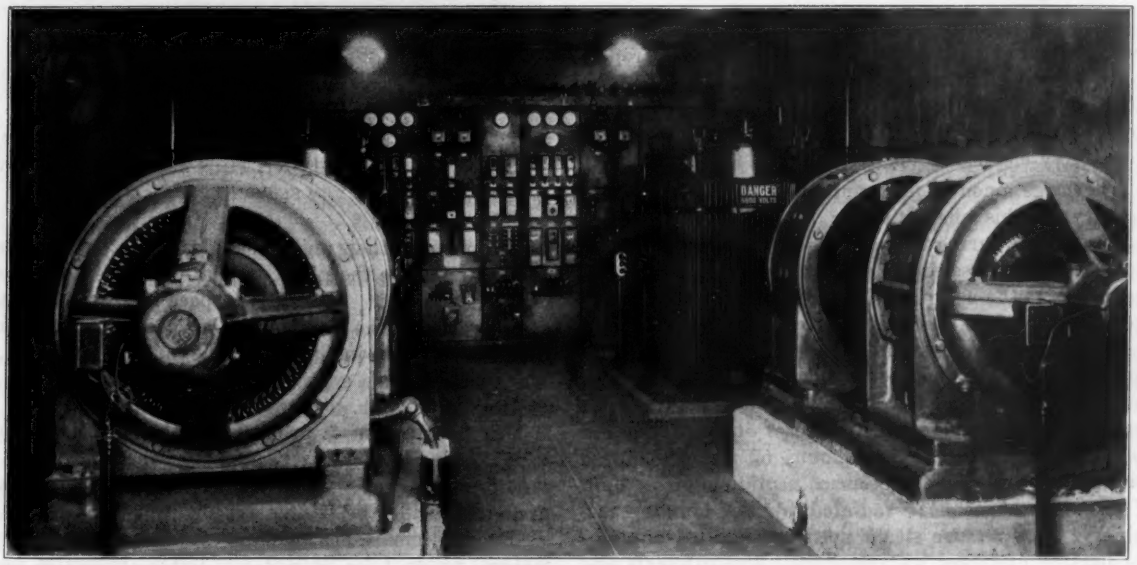
FOR supplying and controlling power, an interesting method is used in the new five-story office building of the McKinney Steel Co. at Cleveland. Mill power is used, but as this is 25-cycle and subject to voltage fluctuations, a substation entirely automatic in operation changes the a.c. to d. c. The use of an automatic substation eliminates operation expense, provides complete protection and allows the equipment to be started or stopped by the janitor of the building and, in case of emergency, by any of the tenants.

This substation the interior of which is shown in the accompanying illustration, uses General Electric Co. twin 100-kw. motor-generators, consisting of 25-cycle, squirrel-cage, induction motors driving three-wire, d. c. generators. With these generators, 230 v. for power and 115 v. for lighting can be secured. In operation, one of the sets is started by means of a remote control push button. If the power supply voltage at the time is sufficient, the motor of this set will be connected automatically to the half-voltage starting tap, and, on reaching nearly full speed, will be automatically connected to full voltage.

If the load on this generator reaches a value beyond that which it can carry without undue heating, the second set starts up and goes on the line automatically. If the combined load is below a certain value and the two machines are under-loaded, the second machine will automatically shut down. The first unit, however, must be shut down manually by means of the remote control switch.

If, for any reason, the first set fails to start, the second will take its place automatically. If both machines have been running and the trailing machine shuts down, it cannot come back on the d. c. line unless the leading machine is carrying load, thus providing reverse power protection.

Incoming lines are protected by overload relays, operating on a line oil circuit breaker, which must be manually reclosed after interruption. Generators are shunt wound and are provided with counter-e.m.f. regulators of the automatic type. These not only hold constant lighting voltage under normal conditions but also lower the load by reducing the voltage if the machines become overloaded. The system is also protected against damage from single-phase starting, alternating current under-voltage, wrong polarity, overheated motor windings, hot bearings, alternating current overload, failure to start, incomplete start, reverse power, direct current under-voltage, continued unbalance of system, grounding of motor or generator windings and overload on incoming lines.



THIS AUTOMATIC SUBSTATION CONTAINS M.-G. SETS FOR CHANGING 25-CYCLE A. C. TO D. C., TOGETHER WITH ALL AUTOMATIC AND PROTECTIVE DEVICES

Balancing Steam and Power Loads in Laundry

CAREFUL ANALYSIS OF ALL CONDITIONS IN NEW LENNOX LAUNDRY, MT. VERNON, N. Y., LEADS TO INSTALLATION OF TURBO-GENERATORS. BY G. RICHARD LUDLOW*

AT MOUNT VERNON, New York, the new Lenox Laundry consists of a modern three-story reinforced concrete, sanitary, fireproof, daylight building, Fig. 1, with a complete system of fire protection, containing 35,300 sq. ft. of floor area. It is used entirely for finished family laundry service, no wet wash work being done. To prevent condensation on the under side

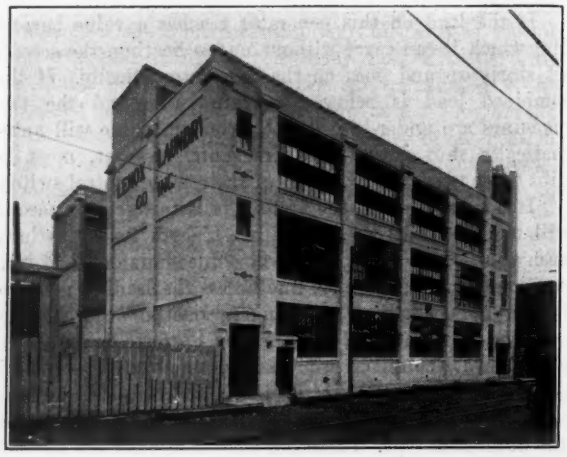


FIG. 1. LAUNDRY BUILDING CONTAINS MOST MODERN TYPE OF LAUNDRY MACHINERY

of the roof during extreme cold weather, the roof is insulated by a layer of cork placed between the roofing and the concrete roof slab.

Laundry machinery is of the newest and highest quality and is laid out with all departments proportioned so that additional machinery can be added in the future to double the capacity of the plant without additional building construction. Individual 3-phase, 60-cycle, 220-v electric motor drive is used throughout.

The large amount of low-pressure steam used in an industry of this character for heating hot water for the wash room during 12 mo. of the year is the determining factor in the selection of a private power plant in preference to the use of public service. The power plant problem, therefore, resolves itself into the selection of the proper prime mover and other power plant equipment to furnish the most economical balance of exhaust steam produced and low-pressure steam required for heating and other industrial purposes during the major portion of the year. The amount of steam required for heating the building becomes negligible on account of the amount of heat radiated by the laundry machinery; low-pressure steam need be supplied only for the heating of offices, garage, store room, cafeteria and locker rooms, and for heating the building before the working day is started and before the heat radiated by the machinery becomes effective.

A factor of 1.9 gal. of water at 180 deg. F. per pound of material washed was derived and the amount of exhaust steam necessary to produce this amount of hot water for the estimated output of the laundry was calculated. To this was added the amount of steam required for heating the make-up water for boiler feed, thus determining the amount of exhaust steam which should be produced by the power plant during that portion of the year when no heating was required. The daylight load on the electric generators was based upon the total connected motor load with a calculated load factor of 58 per cent at 78 per cent power factor. From these data, it was found that the proper steam consumption of engines or turbines driving the electric generators should be 48 lb. of steam per kilowatt-hour at the switchboard for the daylight summer load.

GEARED TURBO-GENERATORS WERE SELECTED

Therefore two 120-kw., 80 per cent-power factor, 900-r.p.m., 3-phase, 60-cycle, 220-v., turbine-driven generators were selected, of single-stage, single-reduction double herringbone gear type, the turbine speed being

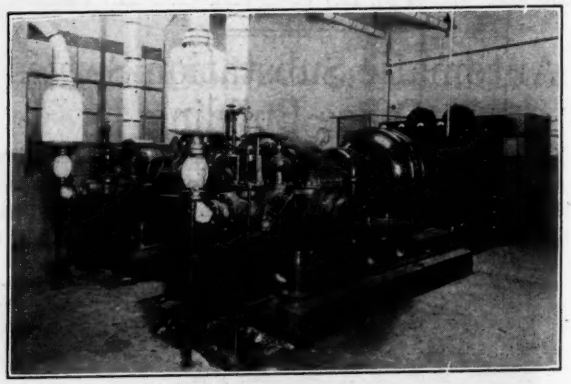


FIG. 2. EITHER OF THE 120-KW. TURBO-GENERATORS CAN OPERATE THE PRESENT PLANT, THUS ASSURING BREAKDOWN SERVICE

5150 r.p.m. Either unit at ¾ load has sufficient capacity to operate the plant, so that complete breakdown service is assured. In addition, space is provided in the engine room for the future installation of a third turbine when the increase in the size of the laundry demands it. The turbines have a guaranteed steam consumption at ¾ load of 46.9 lb. at zero back pressure and 49.5 lb. at 5 lb. back pressure; proper steam balance is obtained by operating at low back pressure when no steam is required for heating the building, and at high back pressure during the winter season.

Boiler room is designed for the installation of two 200-hp. water tube boilers for 160-lb. pressure, hand fired with shaking grates. One boiler was installed and complete provision was made for the second boiler and all feed water heaters, boiler feed pumps, chimney and piping proportioned accordingly. All equipment is installed and designed so that the boiler can be operated normally at 125 per cent load and at higher loads during peak demand with forced draft. The entire plant can

*Managing Engineer, Francisco & Jacobus, Engineers and Architects, New York.

be operated by one man in the firing room with occasional supervision by the chief engineer in the engine room.

Ventilation of a laundry is a very important feature, since during hot weather the efficiency of the employes is greatly impaired and in hot weather the labor turnover is exceedingly great. In this plant the combined heating and ventilation is obtained by the installation of supply and exhaust blowers in pent houses on the roof of the building connected to all floors and machines by a supply and exhaust duct system. The ventilation equipment is calculated for a 5-min. air change in the wash room and flat work departments and a 3-min. air change in the press and finishing departments; the results obtained from this ventilation system have been satisfactory. Tests made during some of the hottest days showed that the temperature within the building was on an average of 8 deg. lower than the temperature on the street. This results from the air being taken above the roof and the evaporation of the moisture in the building by the continual change of fresh air, since no air washer or other cooling device was installed. The heating of the building, exclusive of offices and toilets is accomplished by the insertion of a bank of heating coils in the air supplied to the building by the intake fan, but it is necessary to use these coils only in the early morning for heating up and during severe cold weather.

Three-Finger Bill Gives the Chief a Few Pointers

THE NEW CHIEF FINDS THAT CONDITIONS IN THE BOILER ROOM ARE NOT CONDUCIVE TO EFFICIENT OPERATION. BY A. R. KNAPP

JAMES TERRY was chief engineer of the Central State Prison for Men. The initials C. E. after his name on the prison stationery were purely decorative for he was, in fact, the day operating engineer. The shift engineer had been removed for the sake of economy shoftly after Terry had taken the position of chief. He had a world of prison help about the plant, mostly young men, inexperienced and shiftless. By pulling on a pair of overalls he had managed to learn the layout well enough to carry on and with the usual breakdowns and blowouts which characterize most prison plants, he was able to hold his own.

One morning when he was making his usual inspection of the plant, Terry encountered "Three finger" Bill, the boiler room repair man. He had taken a liking to Bill, principally because he was plain-spoken and truthful, human virtues rarely found within prison walls.

"Mornin', chief," greeted the big boiler repair man.

"Good morning, Bill," replied Terry. "How are you making out with No. 1 boiler?"

"Slowly, sir. I have all the caps off the front headers. The unit ought to be turbined from top to bottom. You see, the chief before you would only let me clean the lower three or four rows of tubes. Said they did most of the work anyway and the others didn't need much cleaning, only washing out. As you know, ordinarily we use river water, but occasionally we have to switch to well water. Step around to the boiler front and I'll show you just what I mean."

Terry climbed upon the stoker frame and surveyed the lower rows of tubes. They were moderately clean, only a thin layer of scale and mud on the inner surface. The higher he looked the more solid the tubes were choked. The three upper rows had openings the size of one's thumb.

"Some of that, chief, can be washed out," Bill remarked as he motioned to the upper rows of tubes. "But there is at least a half inch of hard scale in those tubes that no amount of washing will take out. The back risers from the headers to the drum are choked—three of them completely—can't see how the water circulated in this unit. See those tubes," and he pointed a black finger at a number of chalk marks over various tube ends. "Those tubes are leaking in the headers. Good tubes, too. Maybe I can save them by expanding the ends. Come around to the rear and I'll show you what I think is wrong."

Bill was digging away some of the soot from under the back row of headers. "See this back wall of brick, chief," he began. "Notice that it's built up tight under the headers as though it were supporting them. But every engineer knows that the headers are supported from above. Now," and Bill endeavored to make his point clear, "there should be clearance between these headers and the top of this wall. A pipe roller or something should be placed under these headers to allow them to move freely, to allow for expansion and contraction in the tubes. Every time this boiler is cut off and put in service again there is a terrible strain on the headers because they are practically fastened at both ends. That's the reason for those chalk marks on the boiler front, chief. I might mention that those headers are cast iron. There is a state law prohibiting the use of cast iron in any boiler intended to be operated at more than 25 pounds pressure, and we carry 130 pounds. Some day there is going to be a wholesale cracking of headers in this layout, and I hope my parole comes before that happens."

Bill saw that Terry was interested and took advantage of the opportunity to unburden some of his troubles to the chief. "Now right here at your elbow is another irritating trouble," Bill continued with enthusiasm, "you'll notice that there is only one blow-off valve on this unit, and it's impossible to keep it tight for any length of time. My idea is that there should be two blow-off valves on every boiler—one that will be water tight at all times. A world of good hot water is going into the sewer every day.

"Then there's another point I want to mention while you're here, chief. The last day this unit was on the line I took a pyrometer reading of the stack gas temperature. What do you suppose it showed?"

"Judging from the looks of those tubes it must be around 800 deg.," Terry ventured.

"You're wrong. It was 370 deg."

"That's fine," grinned Terry. "How come?"

"Here's the reason," and Bill pointed to numerous cracks in the boiler side wall over the fire-box and combustion chamber. "That big crack there will lick out a candle light in a second. The inspection door is just as bad. The back doors fit about the same. The bottom rows of tubes are absorbing what heat the boiler is taking, and the rest is being killed by the cold air leaking in. That accounts for the 370° stack temperature. Stop the cold

air leaks and the stack temperature will probably be more than 800° because of those dirty tubes."

"Anything else wrong with this boiler room?" groaned Terry.

"That's just a sample, chief. You'll find all the units in about the same shape—maybe worse. And here's another thing," pointing to a 4-inch feed water line supplying all the boilers. "That feed line is 90 feet long and you'll notice that there is not a single section of pipe covering anywhere. And you will also note that the pump feeds into the line near the far end. By the time the water gets to the last unit through that 4-inch line, it's not very hot. Feel the line right here."

Terry placed a hand on the bare pipe and was surprised to find that it caused no perceptible discomfort.

"That condition leads to something else, chief," Bill continued. "Step over to the feed water heater and I'll explain. You will see that the pump suction from this heater has very little head; that is, there is very little water above the intake to the pump. As an engineer, you know that hot water pumps should have a good head of water, as it is practically impossible to lift hot water. As a result we have to reduce the temperature of the water leaving this heater to 175 deg. so that the pump will not drop its suction and pound itself to pieces. The heater should be raised or the pump lowered."

"Poor engineering there," commented Terry in disgust.

"Yes. And right over your head is still another example. There are six boiler units in this plant, and only the two latest units have non-return valves on the line from the boiler to the header. The four older units have only one valve, and that is a hand-operated globe valve using a composition disk! It's positively dangerous to go into a boiler drum with only a brittle composition disk between yourself and 130 lb. of live steam. Only a short time ago we intended to let number two unit off for cleaning. We took it out of service according to regulations, but were surprised to find that the pressure on the gage remained the same as on the other units in service. We decided that the valve disk was gone, and had to wait until the following Sunday afternoon to shut down the entire plant. The disk was gone all right—cracked in a dozen places, and part of it missing entirely."

Terry raised both hands in surrender. "I know when I've got enough, Bill. That will do for today. Let me see if I can figure some way to remedy these troubles, then I'll be back for more."

Through the boiler room door Bill watched Terry seat himself at his desk in the engineering department office, open a number of trade catalogs. Bill smiled, and turned a grimy face once more in the direction of a row of boiler fronts.

Refrigeration Data and Problems

BALANCING COMPRESSOR POWER AND CONDENSER WATER COSTS; LIQUEFACTION OF CARBON DIOXIDE; COMPARISON OF STANDARD FLOW METERS; MOISTURE AND HEAT TRANSMISSION IN INSULATING MATERIAL

DISCUSSING the question of cost of compressor power vs. cost of condenser water, R. W. Waterfill of Newark, N. J., began with the assumption that the purpose of a refrigerating installation is to maintain a known and fairly well fixed brine temperature; that although suction load may vary, back pressure of the compressor remains fixed and is a basis of calculation for any given installation. By using an infinite amount of condenser water, head pressure can be reduced to a minimum but no one has available an infinite amount of water. With no condensing water, compressor power would be infinite which is another absurdity. In practice, the water quantity runs from 1 up to 6 gal. per min. per ton of refrigeration and Mr. Waterfill made an investigation to determine where, within these limits, would be found the most economical value. He assumed also that the difference between saturation temperature corresponding to condenser pressure and the temperature of the leaving condenser water would vary only within small limits and might, therefore, be taken as constant.

Considering as variable the indicated compressor horsepower per ton of refrigeration, the rate of increase per ton with increase of condenser temperature and the heat to be removed in the condenser per minute, Mr. Waterfill analyzed and plotted conditions for evaporator temperatures from —20 deg. up to +40 deg., for condenser temperatures from 60 deg. to 120 deg. and for heat removal from 200 to 350 B.t.u. per minute per ton refrigeration. This covers the range of indicated horsepower per ton for the compressor from 0.2 at 60 deg. condenser temperature and +40 deg. evaporator temperature up to 3 for 120 deg. condenser temperature and —20 deg. evaporator temperature.

WATER VS. COMPRESSOR POWER

He then worked out an equation for the actual combined power and water costs for different temperature ranges of the condenser water and, plotting these for various conditions, running from a temperature difference of 6 deg. up to one of 12 deg. and for static heads of from 0 up to 120 ft., curves were worked out which, on analysis, indicated that, as was to be expected, the combined cost of power and water has a minimum for any given set of conditions, coming somewhere between 1½ and 3 gal. of water per min. per ton refrigeration. This combined cost becomes lower as the temperature of the condenser water at the inlet becomes less and also as the temperature of the suction gas becomes higher.

Combining the curves for the various conditions analyzed, a set of curves as between combined horsepower for condenser water pump and compressor and the gallons of condenser water used per min. were plotted on a common sheet and show that for conditions ranging from a static head of from 10 to 40 ft. and for initial temperatures of the condenser water from 70 to 85 deg. with 5 deg. suction temperature, the minimum point of cost comes within the range of 2¾ to 3½ gal. per min. per ton. The curves are, however, very flat near the minimum point so that within the range from 2 gal. to 4 gal. change in the rate of use of condenser water will not materially affect operating economy.

*Abstract of papers presented before the American Society of Refrigerating Engineers at White Sulphur Springs meeting.

Liquefaction of CO_2

In considering this question, J. C. Goosmann of Waynesboro, Pa., raised the question of why there should be any difference in the matter of condensation between ammonia and CO_2 since both have to be coaxed to change from gaseous condition to the liquid form by the well known means of compression and lowering temperature. He stated, however, that differences in behavior distinguished the CO_2 in certain respects from the action of ammonia. That the temperature of condensate leaving the condenser from a CO_2 plant is generally found considerably higher than one would expect and this reaches a disappointing figure when the condensing means are inefficient. Presumably this condition is due to the fact that summer operating temperature usually approaches and often exceeds the critical point for CO_2 which is not the case when ammonia is used. While this operation with CO_2 at a point above the critical temperature often gives a slight loss in refrigerating effect, the loss per ton increases about 3 per cent for each increase of 1 deg. in temperature of condensate above the critical point when single compression is used. For dual compression, this increase averages 2 per cent. It is important, therefore, that condenser temperatures be kept as low as possible and condensation be as effective as possible for the above reason and also because, at temperatures of 86 deg. and above, the condenser work per refrigerating ton will come close to 300 B.t.u. per ton of refrigeration.

Condenser Types

One advantage with the use of CO_2 is that it may be subcooled in the condenser below the temperature of saturation and, discussing the various types of condensers, Mr. Goosmann said that pipe condensers especially those of submerged type were not good; atmospheric condensers may be tolerated where, with high water temperature and deficiency in the water supply, a fairly pronounced evaporating effect of water flowing over the pipes may be obtained but subcooling of the liquid is out of the question with this type; double pipe condensers offer advantages of counter flow and possibility of liquid cooling when the surface is liberal and water quantity ample but few actual condenser installations have these conditions. Moreover, with the usual 1¼-in. inside diameter water pipe, the head required to force the necessary cooling water through the pipe would usually be out of the question.

Mr. Goosmann finds also that shell-and-tube condensers, although one of the best features of apparatus in ammonia refrigeration, are objectionable when applied to the CO_2 plant, because of the high condensing pressure in the shell. This high pressure requires that tubes be spaced rather wide apart in the tube sheet to avoid weakening of that sheet and, when so spaced, diameter of the shell becomes large and walls must be made very thick. Mr. Goosmann favors the shell-and-coil condenser and brine cooler as being the most effective apparatus for liquefaction and subcooling of CO_2, if difficulties of construction can be overcome. Gas enters the shell at high velocity and with great turbulence, strikes the cooling surfaces of the coils and condenses, producing a thin film which rapidly flows toward the bottom, thus reducing gas pockets and skin resistance. As it flows downward, it strikes the colder surfaces until it reaches the bottom at a temperature which approaches that of the incoming water and, when collected at the bottom of the shell, it may be subcooled in the case of CO_2.

One difficulty with condensing CO_2 is that a pressure considerably above that of saturation is required in order to produce liquefaction. For instance, at a temperature of 86 deg., the saturation pressure would be 1040 lb. but it is necessary to increase that to 1100 lb. and in order to be on the safe side it is better to increase this to 1140 lb.

Dual Compression Increases Economy

To improve the CO_2 system, reduction in horsepower per ton is necessary and two means are available, employment of the dual effect in compressing and the use of an expansion cylinder. The first has been successfully developed, while the second remains to be tried and tested.

Mr. Goosmann then outlined the dual compression method which consists of compressing the gas to 1140 lb. then cooling it from 160 deg. down to 86 deg. and allowing expansion down to a pressure of 490 lb. which

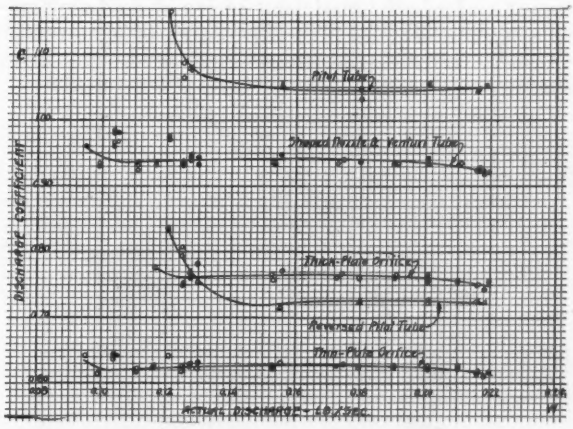


FIG. 1. ACTUAL DISCHARGE AND DISCHARGE COEFFICIENTS FOR FLOW METER ORIFICES

results in temperature of 30 deg. This is done at the sacrifice of 38 per cent of the liquid, which is then compressed by a second compressor from 490 lb. up to 1140 lb. and returned to the condenser. The balance of the charge is cooled in the expansion valve from 30 deg. down to 5 deg. dropping to 334 lb. pressure and is then compressed by the main compressor up to 1140 lb.

Comparison of the two methods shows a saving of over 26 per cent in the horsepower required using the dual method over that required for single compression and an even greater gain is made in the capacity of the plant. Engineers who have used this system in England state from experience that the increase in capacity is from 25 to 122 per cent and reduction in horsepower per ton from 14 to 39 per cent with evaporating temperature of —2 deg. and temperature of condensate ranging from 55 up to 95 deg. Tests made last summer for a machine with like conditions showed an increase of capacity up to 65 per cent and decrease in horsepower of 26 per cent.

Mr. Goosmann called attention to the fact that, since we are working above the critical temperature in the

CO_2 plant, condensation and evaporation may occur in peculiar ways and the change may be slowly passed through in a foggy state or there may be a flashing from liquid into gas or from gas into liquid at certain critical points in the temperature and pressure range. While it is impossible to condense the gas by pressure alone, the density may be increased by increase of pressure to a point where the high pressure gas actually occupies less space than would liquid at the same pressure. Under these circumstances, the gas cannot be liquefied in a given space and it may be necessary to reduce the temperature considerably below that of saturation before the liquid can be accommodated in the space available, when there will be a sudden flashing from a clear invisible gas into a clear liquid.

Mr. Goosmann recognized that absolute scientific accuracy could not be claimed for observations which were made to solve the problems of practical operation but believed that the data and explanations given would

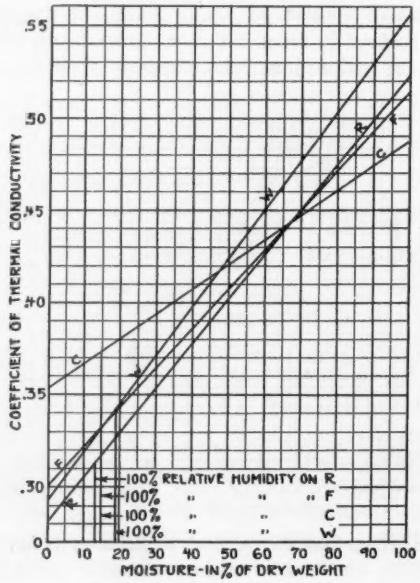


FIG. 2. EFFECT OF MOISTURE ON HEAT TRANSMISSION FOR: W, WOOD FIBER; F, FLAX FIBER; C, CANE FIBER; R, RAG FELT

give better comprehension of the requirements in the successful handling of CO_2 equipment.

Flow Meter Comparison

In a series of tests on standard flow meters connected in series, A. J. Nicholas of State College, Pa., worked out the discharge coefficients for the various forms of measuring devices used, those compared consisting of the Pitot tube, the Venturi tube, the shaped nozzle, thick plate orifice, reversed Pitot tube and thin plate orifice. All these were connected in series and also in series with a Durley measuring box so that the same volume of air was passed through all the various pieces of apparatus, the valve for controlling flow being placed between the meters and the Durley box.

Diameters of orifices for the various pieces of apparatus were as follows: For the Venturi tube, 1½ in.; for the thin plate orifice, 2.014 in.; for the thick plate orifice, 2 in.; for the shaped nozzle, 1.51 in.; for the pipe, 3.068 in. Orifices used in the Durley box were 2.012 and 1.495 in. in diameter. The thin plate had a thickness of 0.065 in. and the thick plate ¾ in. Air was furnished by a high-pressure blower having capacity well in excess of the amount used and air temperatures were taken at the entrance to each piece of apparatus by thermometers having the bulbs exposed to the air in the pipe and inserted through air tight holders equipped with rubber packing.

Tests showed that the leakage through joints was inappreciable and also leakage in the Durley box was found to be negligible. Three tests of 10 min. duration each were taken for each head and rate of low.

Mr. Nicholas calls attention to the fact that such comparison as was made will hold only for a given fluid and, for any other fluid, it is necessary to repeat the method of calibration and secure a new set of calibration curves. It has been found, however, that to make the comparison fundamental and applicable to any fluid and any meter, the basis of turbulence provides the required method, this turbulence being a ratio which is dependent directly on the mean velocity of the fluid through the meter in feet per second, the throat diameter of the meter in feet and inversely on the kinematic viscosity of the fluid passing through the meter. As a standard, the value of turbulence for air at 60 deg. and 14.7 lb. absolute pressure has been adopted. The method of comparison can be found in the Fluid Meters Report for Venturi tube coefficients of the A. S. M. E.

Discharge Coefficient Variations

Results of the tests made were plotted in the form of curves as shown in the illustration herewith and indicate that, for higher rates of flow, the discharge coefficient for the Pitot tube is fairly constant but has a sudden increase at lower rates. It is interesting that the shaped nozzle and Venturi tube have the same discharge coefficient at practically all rates of flow. The thick plate orifice has a curve the same, practically, in shape as that for the Venturi nozzle, but the coefficient is considerably less. The reversed Pitot tube has a curve of the same shape as the regular tube, but with a much lower coefficient, while the thin plate orifice curve follows in shape that of the Venturi tube but has a quite low discharge coefficient.

Mr. Nicholas states that the data for these meters are probably accurate to within 1½ per cent except for the Pitot tubes at the lower rates. Comparison of these values with the coefficients of various meters published shows that a Pitot tube located in the center of the pipe generally has a coefficient of unity and the variation shown in these tests, which is only 0.05, may easily have been due to a slight difference in pipe diameter at the point where the Pitot tube was located. Difference between the results shown and those given in the Fluid Meters Report of the A. S. M. E. may be due to scale effect, because of the small Venturi tube used, which would tend to have a smaller coefficient than the larger tube. It is interesting to note that the thicker the plate in a thick plate orifice, the higher the coefficient and vice versa. The reverse Pitot tube is an empirical instrument and the coefficient will vary with the amount of suction, so that it is difficult to predict the way in which the coefficient will act. The results for the thin plate orifice are somewhat higher than those generally obtained for orifices with square edges

but it was noted that the edges of this orifice were slightly rounded to remove the burr which was formed by punching, which is probably the reason for the greater value shown.

Experimenting on the effect on heat transmission of moisture in insulating materials, L. F. Miller, of Minneapolis determined this effect for four materials, wood fibre, flax fibre, cane fibre and rag felt. It was found that it took a period of some 12 hr. to obtain a stable condition before observations could be started. It was found also that moisture moves across the material from the warm side to the cold side so that, for the higher degrees of moisture, the cold surface becomes wet but the measure of heat transmission can be fairly well made in 3 to 5 hr. before moisture seems to start moving across, if adjustments are made frequently in the apparatus.

In making tests, all samples were first thoroughly dried and the corresponding heat transmissions noted, then moisture was added and observations of the transmissions taken at 5 points about equally spaced varying from about 37 per cent up to 98.6 per cent humidity.

Attempt was made to keep the relative humidity of the room in which measurements were made as nearly as possible that at which the sample was humidified and weighing showed that only 1 or 2 per cent loss in moisture of the insulating material occurred during the test which would be practically negligible. Results of the experiments are shown in the illustration and indicate that the rate of heat conductivity is materially affected, so far as the materials tested are concerned, by the amount of moisture which these materials have absorbed. It is important, therefore, that insulating materials be kept as dry as possible.

New Coal Handling System Enlarges Facilities

NEW EQUIPMENT AT EDDY STREET STATION WORKS WITH OR INDEPENDENT OF OLD SYSTEM TO MEET DEMANDS OF RECENT ADDITIONS. BY O. S. RICHARDSON*

EXTENSIVE ADDITIONS were made during 1925 and 1926 to the Eddy Street Plant of the Narragansett Electric Lighting Co., including four large boilers and a 35,000-kw. turbo-generator. The new boilers were built to use pulverized coal and six of the old boilers were changed to the same kind of fuel. A new coal pulverizing house was built at the extreme northwesterly corner of the property, which is over 650 ft. from the harbor line and about 350 ft. north of the boiler house.

All coal is received by steamers or barges direct from Norfolk and is generally Pocahontas or New River screenings. The storage area is at right angles to the harbor line and while about 650 ft. long it is narrow, only about 90 ft. wide, for a considerable part of the area. The widest section is about 200 ft.

Originally the coal pulverizing house was connected to the west end of the old coal handling system by 30-in. belt conveyors. The old coal handling facilities were found to be inadequate to supply the additional fuel requirements.

This old system included a high unloading tower, operating a 1½-t. two-rope grab bucket driven by a direct-connected steam engine. From this tower coal was crushed and sent either by belt conveyors direct to the bunkers in the old boiler house or by bucket conveyors to the storage pile and coal pulverizing house. After a study of proposed new systems, it was decided to leave the old system intact and build a new system that could be used independently or in conjunction with the older machinery. The site was unusually congested with permanent structures that had to be circumvented and kept in operation. This complicated both the design and construction of the supporting structures.

BARGES ARE UNLOADED BY A BUCKET DROPPED FROM A 55-FT. BOOM

Along the dock a new structural steel trestle was built 27 ft. high and 175 ft. long with rails on 26-ft. centers. On this trestle is a movable discharging tower equipped with a 1½-t. two-rope bucket operated by a one-man control. The boom is 55 ft. long and has a universal hinge at the inner end. The whole tower is electrically operated with 550-v., 3-phase, 60-cycle current. The breakdown capacity is 300 t.p.m.

The main hoist machine has a single gear reduction

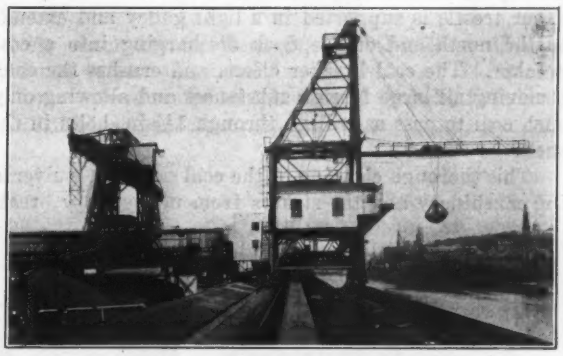


FIG. 1. COAL IS RECEIVED BY STEAMER OR BARGE DIRECT FROM NORFOLK

and the two drums are mounted loosely on the main shaft. The friction end of the drums engages a center air-cooled friction member and is operated from two levers in the cab through a twin screw thrust mechanism and spring release. The motor shaft is equipped with a non-reversing automatic brake. The machine is driven by a 375-hp. motor with special non-reversing panel and master control, operated by a foot lever in the cab. The trolley machine is single drum slip friction drive with one gear reduction. On the motor shaft is an automatic brake operated by a special magnet arrangement. The machine is driven by an 80-hp. motor with special panel and control.

The operation is controlled by latches on the hoist levers in the cab. The trolley is of a tandem type with cast steel sheaves and rope guards and the tower is mounted on 12 double-flanged wheels, six of which, three on each side, are worm-driven by a 30-hp. motor with a reversible drum controller. A boom hoist machine is provided consisting of a 10-in. diameter drum

*With Jenks & Ballou, Engineers, Providence, R. I.

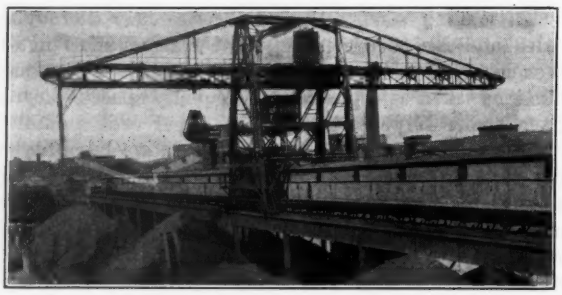


FIG. 2. THIS MOVABLE STOCKING AND RECLAIMING TOWER HAS ARMS EXTENDING 73 FT. ON ONE SIDE AND 83 FT. ON THE OTHER

with a direct-connected reversible 5-hp. motor. An automatic guy is used to prevent turning of the bucket. After coal is dropped into the receiving hopper it runs by gravity to a 42-in. belt feeder driven by a 5-hp. variable speed motor so that an even flow of coal may be sent away from the tower.

Along the back of the tower trestle is a 36-in. belt conveyor rated 400 to 600 t.p.m., at the tail end of which is a chute from the old coal tower so that both old and new towers can feed this belt together. This conveyor is 366 ft. long and is driven by a 30-hp. variable speed motor. The belt conveyor, after leaving the tower trestle is supported in a light galley and extends to the north end of the dock discharging into a coal breaker. The coal breaker cleans and crushes the coal, removing all large foreign substances and allowing only such coal to pass as will go through 1½-in. holes in the shell.

This thorough cleaning of the coal saves the pulverizing machinery and the stokers from unnecessary breakdowns. The only dangerous materials passing the breaker are small pieces of iron which are removed by magnetic pulleys at the head end of the belts near the bunkers. This breaker, driven by a 125-hp. variable speed motor, also keeps wood out of the storage pile, thereby reducing the chances of spontaneous combustion to a minimum.

Coal discharges by gravity to an incline 36-in. belt conveyor under the breaker and is elevated about 42 ft.

EQUIPMENT DATA FOR THE NEW COAL HANDLING SYSTEM OF THE EDDY STREET STATION

Designed by	Jenks & Ballou, Engineers
General Contractor	John M. Proctor & Co.
Belt Conveyors	Stephens-Adamson Mfg. Co.
Coal breaker	Pennsylvania Crusher Co.
Motors for towers	General Electric Co.
Motors for conveyors and breaker	Westinghouse Elec. & Mfg Co.
Machinery for towers	Mead-Morrison Mfg. Co.
Piles driven by	A. A. Hersey Mfg. Co.
Steel work	Berlin Construction Co.
Weightometer	Merrick Scale Co.
Electric wiring (under separate contract)	Carleton Mace Engineering Corp.

and discharged into the field conveyor. The incline conveyor, with a weightometer to weigh the coal on the belt while running, is 137 ft. long and is driven by a 50-hp. variable speed motor.

Field conveyor is 565 ft. long with a tripper for discharging coal along practically its entire length with the option of passing all or part of the load over the head pulley where it is elevated by a 30-in. belt conveyor, previously installed, to the coal house bunkers. The

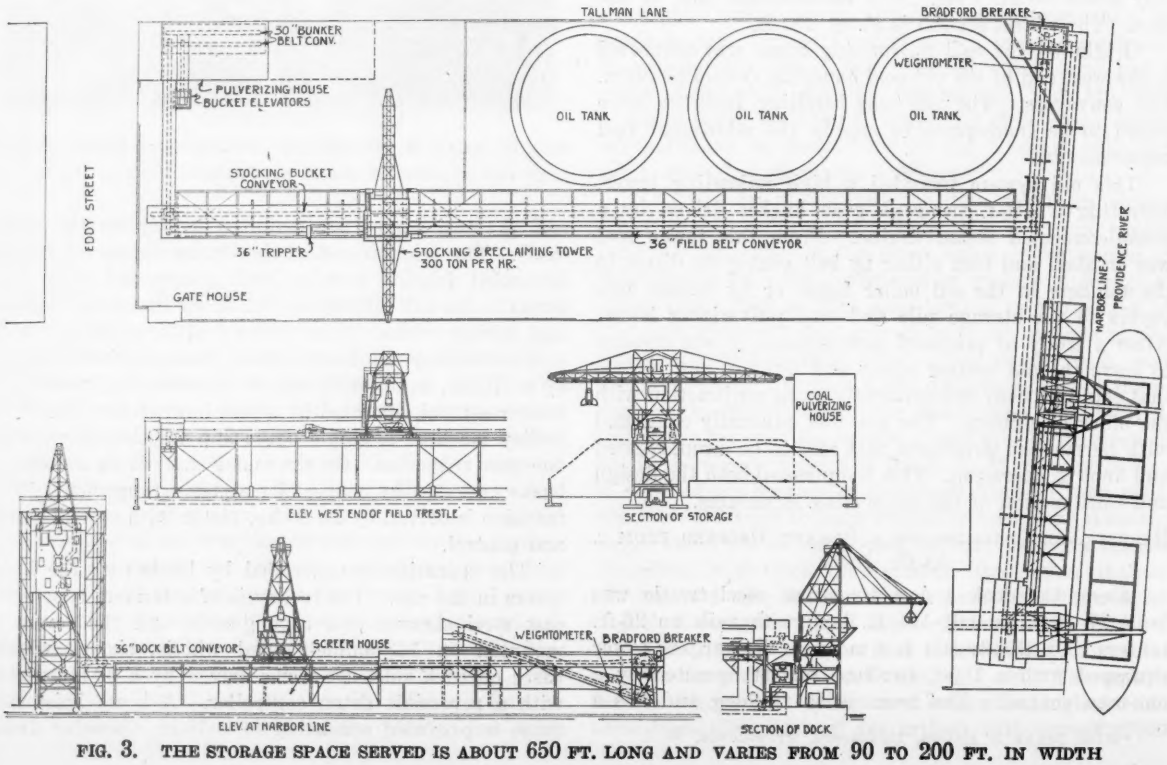


FIG. 3. THE STORAGE SPACE SERVED IS ABOUT 650 FT. LONG AND VARIES FROM 90 TO 200 FT. IN WIDTH

field conveyor is driven by a 50-hp. variable speed motor and is carried on the south side of a structural steel trestle 36 ft. high and 550 ft. long, having rail centers of 30 ft. On these rails is a movable stocking and reclaiming tower with rigid arms extending 73 ft. on the south side and 83 ft. on the north side. This tower is equipped with a 1½-t. four-rope bucket with one-man control and is rated at 300 t.p.m. average capacity. It is operated electrically with 550-v., 3-phase, 60-cycle current.

COMBINED CAPACITY OF TWO SYSTEMS ESTIMATED TO BE 275 T. PER HR.

Driven by a 300-hp. motor with special non-reversing panel and master control operated by a foot lever in the cab, the main hoist machine has a single-gear reduction and the two drums are mounted loosely on the main shaft. The friction end of the drums engages a center friction member and is operated from two levers in the cab through a twin screw thrust mechanism and spring release. The motor shaft is equipped with a non-reversing automatic brake. The trolley machine is a single drum with one gear reduction and driven by an 80-hp. motor with special panel and controlled by latches on the hoist levers in the cab. It is also provided with a double-acting foot brake operated from the cab. The trolley is a four-sheave type with cast steel sheaves and wheels. The tower is mounted on four two-wheel trucks.

Four wheels, one on each truck, are worm-driven by a 40-hp. motor with a reversible drum controller. When reclaiming, coal is dropped by the bucket into a hopper from which it runs by gravity to a 42-in. belt feeder driven by a 5-hp. variable speed motor to give an even distribution of coal to the field conveyor. The service of this tower is varied from stocking out the tripper discharge to all kinds of reclaiming and moving operations. It reclaims coal for the coal house or to the old tunnel bucket conveyor where coal can go to either the coal house or to the old boiler house bunkers.

It is estimated that by using both old and new discharging towers, a 5000-t. steamer can be unloaded in from 16 to 18 hr. as an actual unloading of 5200 t. has been accomplished in 18 hr. The station is now using between 800 and 1000 t. daily which is expected soon to be increased to from 1100 to 1200 t. a day.

Melones Hydro Plant Uses Irrigation Water

BY PURCHASING FOR POWER GENERATION WATER IMPOUNDED BY OAKDALE & SOUTH JAN JOAQUIN IRRIGATION DISTRICTS, THE PACIFIC GAS & ELECTRIC CO. HELPS TO FINANCE THE IRRIGATION PROJECT. BY C. W. GEIGER

AMONG THE HYDRO-ELECTRIC developments that have recently been attracting attention in California is the Melones Dam project on the Stanislaus River, described in this article. On June 11, the Melones power plant, with a capacity of 34,000 hp. in two vertical water wheel units, was formally placed

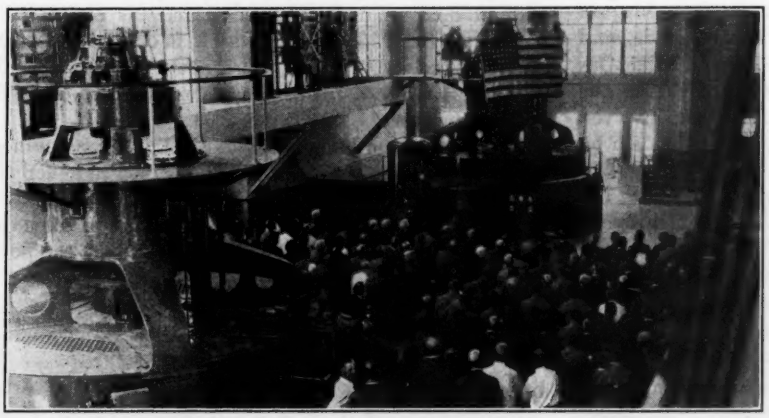


FIG. 1. LEFT—GUESTS AT DEDICATION CEREMONIES AT OPENING OF MELONES PLANT ON JUNE 11

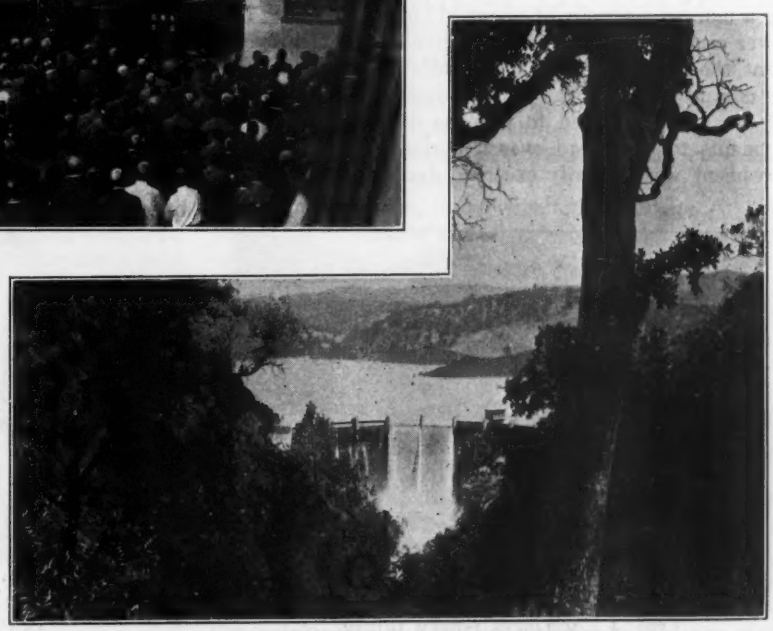


FIG. 2. RIGHT—MELONES DAM, BUILT BY THE IRRIGATION DISTRICT, CREATES A STORAGE RESERVOIR OF 112,500 ACRE FEET, WATER BEING USED BY POWER COMPANY BEFORE GOING TO IRRIGATION USERS. POWER COMPANY MAKES PAYMENTS FOR THIS WATER FOR 40 YR. FOR GENERATING POWER, AFTER WHICH IT RECEIVES WATER FREE BUT SHARES COSTS OF MAINTAINING DAM

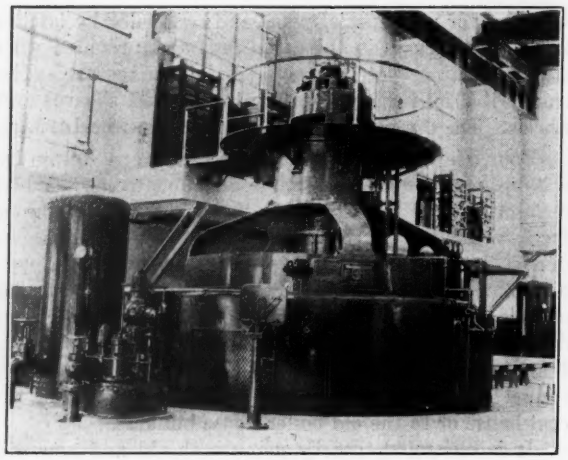


FIG. 3. NUMBER TWO 13,500-KV.A. GENERATOR AND GOVERNOR. GENERATOR FIELD RHEOSTATS ON BALCONY, WITH RUNWAY TO EXCITER PLATFORM TO GIVE EASY ACCESS AND SHORT CONNECTIONS

in service at an elaborate ceremony attended by press representatives, engineers and prominent utility officials.

This project is incorporated in a development brought about by an agreement between the Pacific Gas & Electric Co. and one of the irrigation districts, whereby the water impounded by a dam of the irrigation district is purchased by the power company for power generation, after which it is sent on to the irrigation users, while the power thus made available is distributed throughout the territory.

The agreement is between the South San Joaquin and Oakdale Irrigation Districts, on the one side, and the Sierra & San Francisco Power Co. and Pacific Gas & Electric Co. on the other, the latter operating the properties of the former under a lease. This involved the construction by the irrigation districts of a dam on the Stanislaus River, near the town of Melones, creating a storage reservoir of about 112,500 acre feet. The power companies, on their side, agreed to build a hydro plant, the Melones plant, about a mile down stream from the dam to be operated by water diverted thereat. For this water they agreed to pay the districts $5,175,000, payments to be spread over a period of 40 yr. This agreement was formally executed January 15, 1925.

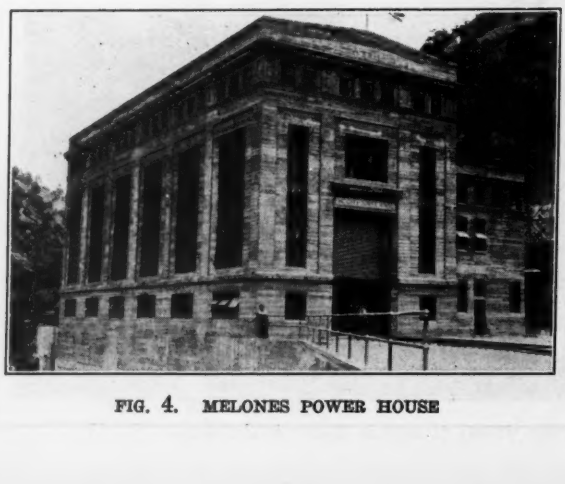


FIG. 4. MELONES POWER HOUSE

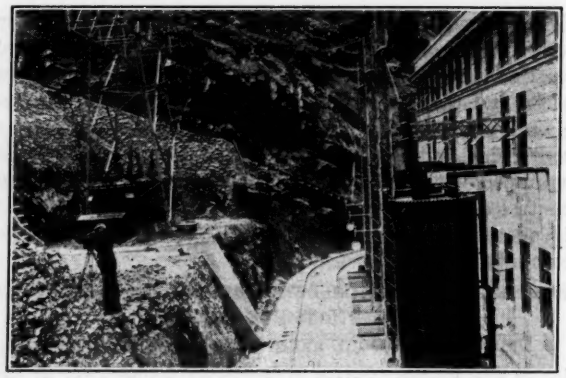


FIG. 5. THESE 6600/110,000-V. TRANSFORMERS STEP UP POWER FOR TRANSMISSION 42 MI. TO MANTECA SUBSTATION. OUTDOOR SWITCH STRUCTURE AT LEFT

It was agreed that the irrigation districts should control the river flow from March 1 to November 1, the power companies the remainder of the year. After the water is used for power generation, it is to be returned to the Stanislaus River, down which it will flow some 8 mi. to Goodwin dam, where it will be diverted into the districts' canals for distribution to irrigation users below. At the end of 40 yr. when the stipulated payments will have been completed, the power companies will enjoy perpetual use of the water from the dam for power generation, the sole charge upon them being that of sharing equally with the irrigation districts the cost of maintenance.

Contracts were ratified by the people of the districts concerned on May 18, 1925. Construction was started without delay and the Melones Dam was completed in the fall of 1926. This dam, Fig. 2, is of constant radius concrete arch type, 210 ft. high above bedrock and 585 ft. along the crest. It is the second highest over-pour dam in the world.

Meanwhile the Pacific Gas & Electric Co.'s engineers lost no time in starting work on the power generating end of the project. The irrigation districts' construction work stopped at the irrigation outlet, approximately 405 ft. below the Melones dam. At this point the power

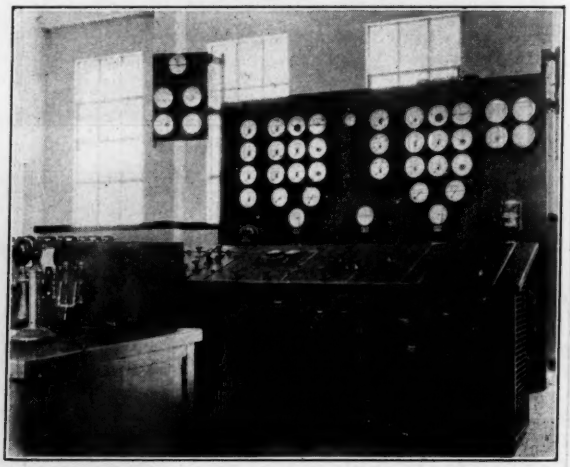


FIG. 6. OPERATOR'S CONTROL DESK, WITH INSTRUMENT AND RELAY BOARD BEHIND IT

development project begins with a concrete-lined pressure tunnel, 4400 ft. long, of horseshoe section, 12 ft. in diameter and of 1500 c.f.s. capacity. From the down stream end of this tunnel two short pressure tunnels 8.5 ft. in diameter take the place of penstocks to carry water to the power house.

Length of the steel penstocks joining these pressure tunnels to the power house is kept to a minimum as determined by the stability of the ground adjacent to the power house after excavation. It was found possible to continue the pressure tunnel to within 112 ft. of the companion flange of the butterfly valves at the turbines. The steel penstocks thus serve merely as connecting pipes between the ends of the pressure tunnels and the turbines. These steel penstocks are 5/8-in., triple-riveted, double-butt-joint pipe, 102 in. inside diameter. The penstocks, except for the 6 ft. of projection into the power house, are imbedded in concrete.

Between penstocks and turbine casings are installed 8 ft. 6-in. butterfly valves. The control mechanism permits closing these against the full load discharge of the turbine, under a maximum static head of 235 ft. with either manual or motor operation and a 9-in. gate valve bypass is installed with each turbine butterfly valve. No surge tank or other form of pressure relief is provided in the pressure lines, full dependence being placed on the main relief valves at the turbines.

Turbines consist of two units of the single-runner, vertical, Francis type, of approximately 17,000 hp. maximum capacity. At a rated speed of 277 r.p.m. they are each designed to discharge 760 c.f.s. under an effective head of 200 ft., although the best efficiency is expected at heads ranging from 190 to 210 ft. and high efficiencies are expected at all heads from 150 to 225 ft. Since 86 per cent of the total output will be generated under heads of 150 ft. or higher, this design is intended to give good overall efficiency.

Two generators each have a capacity of 13,500 kv.a., at 90 per cent lagging power factor, designed to carry the maximum load developed by the turbines when passing 1600 c.f.s. under an effective head of 228 ft. This is possible because power factor conditions on the system permit operating at practically unity power factor; also, the generators will have Class B insulation with a 50-deg. rise in temperature at normal ratings. The units generate at 6600 v.

The power transformer bank consists of three 9000-kv.a., 11,000/115,000-v. units, single-phase, oil insulated, water-cooled, of the outdoor type, with one similar spare unit. A bank of two 100-kw. and one 150-kw., 6600/220-v. transformers, fed from the generator bus, supplies the station lights and power. These transformers furnish starting power for the spare exciter motor by means of center taps for 110 v.

The power house is of structural steel and reinforced concrete and includes two floors and a turbine pit. The generator room is on the main floor, giving convenient access to the generators from the switchboard, which is also on this floor. The switchboard room is glass enclosed on the side toward the generators. A 75-t. crane, large enough to handle any equipment in the plant, is installed.

As noted above, the Melones plant was placed in service with a formal ceremony on June 11. About 275 California newspaper editors, together with many engineers and officials of the company were taken by automobile through the irrigation district to the plant. Figure 1 shows the party assembled in the generator room to hear speeches by John Hancock, representing the Oakdale and South San Joaquin irrigation districts and C. P. Cutten representing the Pacific Gas & Electric Co. Miss Hazel McFarland pressed the button that started the units in operation. R. E. Fisher, vice president of the company, presided over the meeting.

Problems in the Use of Water Wheel Governors*

Discussion of Possibility of Omitting Governors Entirely, Together with Data on Various Governor Details and Operating Problems

SEVERAL PLANTS have been installed recently in which governors for hydroelectric generating units, or at least sensitive speed control, have been omitted. Instead, means of slowly closing the wicket gates or the penstock valve ahead of the turbines have been employed. In view of the possibility of saving some part of the capital cost of a project, by eliminating a part of the governor mechanism, the surge tank, and so on, consideration of the desirability of such construction was assigned as one of the subjects for study by a subcommittee of the N. E. L. A. Hydraulic Power Committee, which reports the following data.

In such installations the control of the water entering the turbine may be by: (1) Wicket gates operated by a standard governor set to open and close at a predetermined slow rate; (2) Wicket gates operated by some form of hydraulic, mechanical or motor-driven device having a predetermined time element; (3) A valve or valves in the penstock ahead of the turbine set to operate in not less than a predetermined time. In this case the wicket gates would be stationary and would either replace or consist of extensions of the customary speed ring or stay vanes.

From the above, it is evident that in case (3), the turbine may operate at full gate opening only and, in case of dropping of load, will attain full run-away speed unless a satisfactory synchronous bypass or a shunt for the load is provided to hold the speed down until the gates or valve can be closed. In cases (1) and (2) the gate opening may be adjustable, but for any but small gate openings, runaway speed may be attained if the load is suddenly cut off. The generator and turbine must, therefore, be designed to withstand safely any possible overspeed.

Conclusions reached from a study of the available data are as follows:

1. It is feasible to install units without sensitive speed control, provided:

(a) They are so located that if disconnected from the system, they will not be required to feed any load.

*Abstract of 1926-27 report of Governor Problems Subcommittee of N. E. L. A. Hydraulic Power Committee.

(b) They are of moderate aggregate capacity connected to the system at that time—say not over 25 to 50 per cent of the operating capacity or connected operating load. Opinions vary as to this percentage.

(c) The units are designed to withstand full runaway speed and are provided with means for opening the generator field circuit when overspeeded to a predetermined extent.

(d) The operating requirements and standards of the system will permit of the time required for and the voltage and frequency disturbances likely to be caused by synchronizing and throwing on the line units of the designed capacity.

2. Since the cost of a complete governor is a small part of the cost of a development, its complete elimination or the substitution of other automatic means of closing the gates or valves will result in no appreciable saving in capital cost.

3. Unless the rate of closing of valves or gates is timed so as positively to limit to a small value the resulting surge and final impact at gate or valve closing, the elimination of the surge tank or reduction in strength of pipe line, or both, will be unwarranted, and no saving in the cost of these items will result.

Regulation of Load Between Units

On most of the very large systems the regulation or distribution of load between units is maintained by switchboard control of the governors. The majority of companies depend upon the inherent governing capacity of the governors, with the addition of a stop, as the load limiting device.

When operated on base load, the regulations need be only such as to prevent injurious overspeed on dropping of load. For peak load operation, taking the swings, an inherent speed regulation of 2 to 3 per cent is considered by some of the companies reporting to be necessary for satisfactory frequency control. For base load operation, a regulation of 4 per cent to 5 per cent is found satisfactory by the same companies. For small stream-flow plants connected into large systems and not directly connected to a load, the inherent speed regulation is relatively unimportant. Some manipulation of the governor is necessary in order to maintain the desired regulation.

Types of Governor Drives

The belt drive, with idler, is reported as giving general satisfaction, particularly where the double belt drive is used. Several companies expressed opinion regarding motor driven flyballs operated from an auxiliary generator on the main shaft of the unit. The general opinion seems to be that this form of drive is preferable to and more dependable than motor drive from the main generator leads or bus.

Types of Governor Oil Pumping Systems

The central oil pressure system with separate motor driven pumps and spare water wheel driven pumps has, where used, been reported to be entirely satisfactory, and results in a minimum number of pumps to be operated. Satisfaction was reported with pumps having combination motor and water wheel drive, with sufficient spare units. Some of the companies have had entire satisfaction with motor driven pumps only. Some of the companies prefer individual governor oil pumping systems for each unit, while others also prefer that these individual units should be interconnected with each other and with a spare unit for use in case of breakdown.

The gear type of pump is almost universally used for governor oil pumping. Some companies are using the screw type of pump with satisfactory results.

Special Means for Limiting Swings in Frequency

The setting of the governor to close the gates at as great a speed as is practicable is the only means reported for keeping down swings in frequency. Where heads are high or pipe lines long, the speed of gate movement must be slow and frequency variations may be excessive.

Control of Load Limit Devices

All but two of the companies reporting emphatically expressed the opinion that these devices should be subject to the fullest control from the switchboard. In the case of the two exceptions mentioned, the preference was expressed for hand control by the floor operator at the governor, on the ground that these changes are made infrequently.

Some engineers reported that they have considered the addition of a device to the governor which would limit the load to be carried by a unit, but would permit full load to be picked up automatically in case of trouble. Such a device has not been produced largely, it is said, because the governor manufacturers believe there is little or no demand for it. Should there be sufficient demand, such a device could be developed and standardized, and could be furnished at a reasonable price.

Wall Plugs for Mounting Equipment

Frequently, walls must be plugged in order to support fairly heavy weights such as motor starters and hangers. And, not infrequently, such plugs shrink and become loose. This trouble may be largely avoided by making the plug in two parts, one of these wedge shaped, while the other is forked and long enough to receive the entire length of the wedge. The forked section is similar to the ordinary clothespin. Undercut the hole in the wall with a chisel so that it is slightly larger at the bottom than at the outer end. Place the wedge within the forked section, wedge-shaped portion inwards and drive the plug into the hole until the blunt end is flush with the wall. Further hammering will now drive the wedge into the fork, thus expanding the plug to a tight squeeze. Such wall plugs seldom work loose.

Total production of soft coal during the week ending June 11 is estimated at 8,522,000 net tons, according to recent announcement by the Department of Commerce. This shows the highest output recorded since the beginning of the suspension on April 1. Compared with the weekly rate of production in May, there is an increase of 1.9 per cent. The total quantity of soft coal produced during the calendar year 1927 to June 11 amounts to 253,862,000 net tons. Total production of anthracite during the week ending June 11 is estimated at 1,732,000 net tons.

Making a Safety Engine Stop Safe

UPON TAKING charge of a steam plant, I found one engine had an extra pulley on its crankshaft alongside of the regular flywheel as shown in Fig. 1. Because of the obstruction caused by the rim of the pulley, it had been necessary to place a standard, which held a shaft

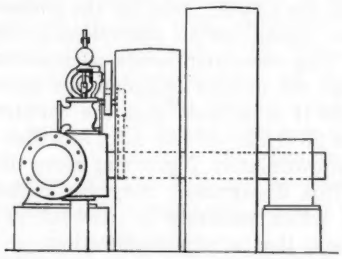


FIG. 1. SHOWING HOW EXTRA PULLEY ON SHAFT INTERFERED WITH NORMAL OPERATION OF ENGINE STOP

and two small pulleys, on the engine frame as shown at B in Fig. 2. In this way, one of these pulleys was belted to the engine shaft while the other was belted to the governor pulley.

The standard had been rigidly bolted to the frame. In this case, if the long belt broke or became loose, the engine stop which was of the gravity type in which

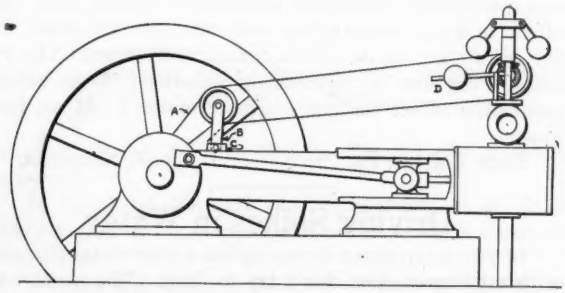


FIG. 2. SHOWING HOW TILTING STANDARD WAS MOUNTED ON ENGINE FRAME

weight D, Fig. 2, is allowed to drop when the tension on the belt is relieved, thus releasing a fulcrum and closing the valve. But if the short belt A, Fig. 2, broke, there was nothing to prevent the engine from racing.

In order to provide for the possible breaking of the short belt, a short piece of $1\frac{5}{16}$-in. diameter shaft was welded to the lower part of the standard, parallel to the shaft supporting the two small pulleys. The lower shaft was then set in bearings which were attached to the engine frame as shown at C. This arrangement permitted the standard to tip back toward the governor if the small belt broke, thus releasing the safety mechanism on the governor. By placing limit stops on each side of the standard, it was prevented from tipping completely over and possibly damaging itself.

Seattle, Wash. N. W. DUELL.

Connecting Transformers Across Proper Phase Increases Output

RELIEVING overloaded distribution transformers of their excessive load simply by changing from open delta to closed delta connection is a new method that was

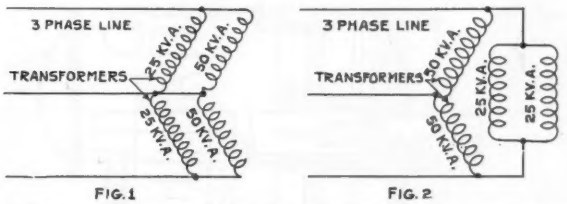


FIG. 1. SHOWING INCORRECT CONNECTION WHICH HOLDS CAPACITY TO 130 KV.A.

FIG. 2. CORRECT METHOD OF CONNECTION WHICH RAISES CAPACITY TO 150 KV.A.

recently brought to the attention of the writer. This was done in a small central station where it was noticed that two 50-kv.a. transformers connected open delta to supply a power feeder were unusually hot and in danger of burning out. It was evident that the transformers were overloaded excessively.

On further inspection of the system it was found that two 25-kv.a. transformers, also connected open delta, which had been added previously to the same feeder, were installed further down the line. These transformers were likewise found hot. The transformers were installed in such a manner that one 25-kv.a. and one 50-kv.a. transformer constituted a set in parallel across one phase and another 25-kv.a. and one 50-kv.a. constituted a second pair across another phase. Diagrammatically the connections were as shown at Fig. 1. New transformers were on order, but it was feared that a burn-out might result before their arrival, and something had to be done with the present equipment if possible. It was evident that the combined capacity of the 50-kv.a. transformers connected in open delta was not 100 kw. but only 86.7 kv.a.; likewise, the two 25-kv.a. transformers had a combined capacity in open delta of only 43.35 kv.a. instead of 50 kv.a., bringing about an aggregate capacity of only 130 kv.a. instead of 150 kv.a.

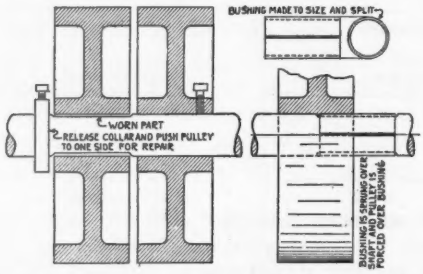
Therefore, the 25-kv.a. transformers was disconnected from the feeder and connected in multiple with

each other, and this multiple set was connected across the open phase as shown at Fig. 2. With this combination a closed delta existed and the full capacity of 150 kv.a. was obtained, representing an increase of more than 15 per cent. The load on the transformers was still in excess of 150 kv.a. but there was an appreciable reduction in operating temperature and the overload was carried satisfactorily.

Woodward, Okla. H. J. ACHEE.

Bushing Shaft Worn by Idler Pulley

WHEN AN IDLER pulley on a line shaft wears the shaft after a period of service, it causes pounding and apart from getting out of alinement with the power pulley, also causes belt troubles. It is not practicable at such a time to take down a shaft for the repairs, as this would interrupt the machinery as well as involve a considerable cost for repair. Recently the machine foreman in a certain shop made and installed the bushing repair shown in the illustration. This repair job cost little and was made without interfering with the operation of the line shaft. The shaft and the inside of the pulley were measured as near as practicable.


BUSHING MADE TO SIZE AND SPLIT
WORN PART
RELEASE COLLAR AND PUSH PULLEY TO ONE SIDE FOR REPAIR
BUSHING IS SPRUNG OVER SHAFT AND PULLEY IS FORCED OVER BUSHING

SHOWING HOW SPLIT BUSHING IS SPRUNG OVER WORN PART TO PROVIDE NEW BEARING FOR LOOSE PULLEY

The bushing shell was then made of a diameter that allowed for a $\frac{1}{16}$-in. saw slot. The bushing was then opened and sprung on the shaft, the pulley having been pulled out of position. The bushing was then bent back to shape in the space caused by the wear and the idle pulley was driven over the split bushing. This complete job worked well, overcoming all the previous trouble.

Washington, D. C. G. A. LUERS.

Counterflow and Uniflow Non-Condensing Engine Economics

COMPARISON of counterflow and uniflow engine economics are generally made on the basis of steam rate per i.hp-hr., or B.t.u. per hp-min. This, however, is insufficient since the operating range of pressure and temperature for the two engines is usually not the same. In order to make the results comparable, it seems desirable to choose engines of equal horsepower in both types and evaluate the consumption on the B.t.u. per hp-min. basis. Then reduce the results of one of the engines to the operating range of pressure and temperature of the other. The writer has taken data for counterflow and uniflow non-condensing engines and reduced the results for comparison purposes to the above basis. The uniflow engine was a 15 by 16-in., 250-r.p.m., 170-i.hp. engine operating at 150 lb. pressure and atmospheric exhaust. The counterflow engine was a 16 by 22-in., 260-i.hp. Corliss engine operating at 200 r.p.m., 150 lb. pressure and atmospheric exhaust. The uniflow engine was jacketed on the head and cylinder. The steam in both cases was dry or nearly dry and saturated. Both engines operated at the same pressures. Comparison on the B.t.u. per i.hp-min. basis is therefore directly comparable, provided the same i.hp. is taken into account. This was assumed at 170 for both engines.

The results for the uniflow engine were as follows:

i.hp.	56.2	94.8	132.6	174
Actual B.t.u. i.hp-min...	350	340	347	355

From the curve plotted with the preceding values, the B.t.u. per i.hp. per min. at 170 hp. is found to be 353. The Corliss consumption at 170 i.hp. was 21 lb. of steam. According to Peabody, a gain of 7 per cent in the steam rate economy would have been obtained if the cylinder had been jacketed. This amounts to 1.5 lb. of steam per i.hp-hr., making the correct steam rate 19.5 lb. per i.hp-hr., or an equivalent of 330 B.t.u. per i.hp-min. This correction seems permissible in view of the fact that the uniflow cylinder was jacketed. From these results it is evident that the counterflow engine operated on 23 B.t.u. per i.hp-min. less than the uniflow, which is approximately 7 per cent more than the counterflow. This discrepancy may be explained by the minor loss which probably is inherent in the uniflow principle, and that is super-saturation.

It is probable that this effect does occur in the uniflow engine in view of the fact that the initial condensation loss is so effectively realized that the steam acts as a perfect gas, expanding according to the law $PV^{1.3} = C$. Consequently the heat content per pound of steam at the exhaust is greater than in the case of equilibrium expansion In condensing uniflow engines the fact that the economy is equal to that of compound or triple expansion counterflow engines, the effect of supersaturation is probably not realized, and the engine performs economically in spite of supersaturation. In non-condensing operation, however, it seems that this effect is more outstanding and may be the cause for the difference, as the above comparison shows. The results bring out an interesting question: Does supersaturation affect uniflow engine economy? If so, how much?

State College, Pa. A. J. NICHOLAS.

Driving Spikes in Water

IF YOU HAVE never driven spikes under water directly with a hammer, then don't try to do it. The usual way of driving spikes under water is to procure a piece of pipe barely large enough to receive the spike head and long enough to reach above the surface of the water from where the spike is to be driven. Procure a piece of round steel rod which will slide loosely inside of the pipe. Place the pipe upon the point at which the spike is to be driven, drop in a spike, insert the steel rod and drive against the rod with a hammer until the spike has been forced home.

At slight expense, the above described apparatus may be improved. Obtain a couple of forty penny wire spikes, or better still, two pieces of round tool steel of equal diameter. Point the steel and cut off three or four inches; or if the spikes are used, do likewise to them.

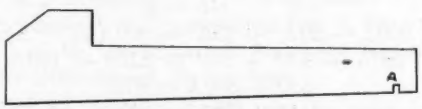
Place the pointed pieces of metal opposite each other on the outside of one end of the spike driving pipe, wire the steel points in their position with their pointed ends projecting ½ or ⅝ in., then fasten the points permanently in position by brazing or oxy-acetylene welding, which is better than brazing. In using this tool, the points will enter the plank and hold the pipe steady while the spike is being driven. After placing the pipe exactly where the spike is to be driven, a tap from the hammer will drive the point into the wood. When using ordinary pipe, it is apt to slip off the spike, when the latter has been driven nearly home, and it is hard or even impossible to replace the pipe and finish driving the spike. The two anchor points obviate all these troubles.

Another improvement consists in making the steel driving rod several inches longer than the pipe. Place a collar, or a "Hex" nut upon the pipe. Let the collar or nut be a drive fit upon the rod and so located as to be at one end of the pipe while the lower end of the rod is flush with the lower end of the pipe. Weld the collar or nut solidly in place and cut off the rod a few inches above the collar. When driving a spike with this improved rod you can tell at any time how far the spike has penetrated. You can also tell when the spike has been driven home and you will not, as sometimes happens when driving with a plane rod, drive it far into the planking.

Indianapolis, Ind. JACK BOSTON.

Using a Loose Key

WHEN A KEY is not large enough for a tight drive a liner is generally used. Often there is difficulty in making the liner move as the key is driven in. If a hack saw is used to make a cut about ⅛ in. deep near the end of the key and a right angle bend is made on



SAW CUT PROVIDES MEANS FOR CAUSING LINER TO MOVE WHEN KEY IS MOVED

the end of the liner to fit into the cut, the problem is solved.

In the sketch the hack saw cut is shown at A. It is obvious that a cut can be made for using a liner on either face.

Toronto, Canada. JOHN THORN.

Making Wire Safety Guards

AN EASY and excellent way in which to make wire guards for almost any kind of machine is to make the framework out of angle iron and the sides out of wire cloth of suitable mesh. First make the frame. Angle iron is not easily bent without cutting out portions of the flange. That is, cut out some V's from the inner flange where the bend is to be made. If the bend is to be 90 deg., cut out a square V. If the bend is to be 45 deg., cut out a 45-deg. V, and so on. In other words, cut out a V whose angle is equal to the bend wanted.

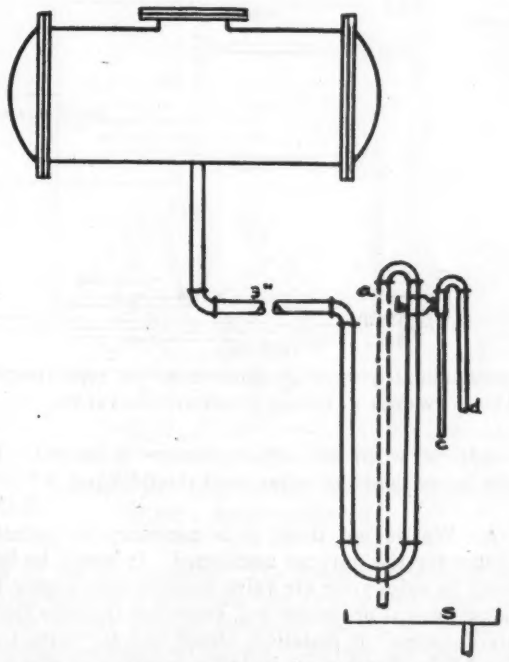
After the frame is formed, put in the wire cloth or screen. The quickest way to fasten the wire in place is via the welding torch. The same torch may be usefully employed for welding the framework together before proceeding with the wire. Simply "spot weld" the wire terminals in place on the inner flange of the frame. It doesn't take much time to do this after one knows how to operate a welding flame. If no welding outfit is available the wire may be either riveted or bolted in place. Punch holes through the inner flange at the wire terminals and then rivet or bolt. When carefully made entirely of metal, a guard should last indefinitely.

Newark, N. J. W. F. SCHAPHORST.

Detection of Leaks in Water Heater Tubes

LEAKY TUBES in a feed-water heater gave us considerable trouble as the condensed steam was wasted often passing through a U trap and return bend A to the sump S to which they were connected by pipe shown dotted in illustration.

It was difficult to tell when a tube was leaking so a tee was put in at B and a ½-in. reduced overflow which



SHOWING HOW ADDITION OF A FEW FITTINGS AFFORDS EXCELLENT TELL-TALE FOR LEAKY WATER HEATER TUBES

was sufficient to take care of water at normal load at C. When, however, the load on the heater was heavy, some water would come out of the 1-in. drain pipe D. If, therefore, a tube started to leak, this would result in a much greater quantity of water coming over than could be handled by the reduced overflow C and water would then be discharged also from D thus indicating a leak in some tube.

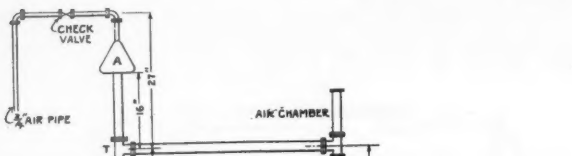
Waverley, Mass. R. B. ROWE.

A TIGHT JOINT is a good investment; a leaky joint is a hazard.

QUESTIONS AND ANSWERS

Preventing Loss Through Air Valve

IN A LOW pressure heating system from which the water of condensation is drawn by an electrically operated vacuum pump, air is expelled through an air valve A located in the exhaust pipe E when under vacuum and under this condition everything works all right but as soon as the pressure reaches 2 or 3 lb. some water is forced out through the exhaust. I am thinking of installing an injector in the exhaust pipe so that it may



CENTRIFUGAL ACTION AT SHORT TURN IN PIPE THROWS WATER IN STEAM THROUGH AIR VALVE

be operated when the higher pressure is desired. How much lower than the water level should I put it?

S. C.

A. We do not think it is necessary to install an injector for the purpose mentioned. It would be better simply to raise your air valve considerably higher than it is at present or, better yet, since you indicate that an "air chamber" is installed, attach the air valve to the top of this chamber or install a receiver at this point and attach the air valve to the top of the receiver.

As you have the air valve now, some of the wet steam, under the higher pressure, which increases proportionately to its velocity, is thrown out when it makes the sharp turn at the tee T. When working under a vacuum, the velocity being lower, sufficient force is not exerted to throw the water even as high as the present height of the air valve.

Another Algebraic Solution to Rate Problem

THE FOLLOWING rate problem, which was solved graphically on page 530 of the May 1 issue, may be solved by ordinary algebra.

The problem is: A and B start at points 300 mi. apart and, traveling toward one another, meet. After meeting, it takes A 6⅔ hr. to complete the distance just traversed by B, and 15 hr. for B to complete the distance just traversed by A. What is their speed per hour?

Let A = miles per hour of A, and B = miles per hour of B, and X = number of hours from start to meeting point.

(1) $XA + XB = 300$

$$X = \frac{300}{A + B}$$

(2) $XA + 6\frac{2}{3}A = 300$

then $$\frac{300A}{A + B} + 6\frac{2}{3}A = 300$$

$$300A + 6\frac{2}{3}A^2 + 6\frac{2}{3}AB = 300A + 300B$$

$$45A + A^2 + AB = 45A + 45B$$

$$A^2 + AB = 45B$$

$$A^2 = 45B - AB$$

$$A^2 = B(45 - A) \text{ and } B = \frac{A^2}{45 - A}$$

(3) $6\frac{2}{3}A + 15B = 300$ or $20A + 45B = 900$

then $$20A + \frac{45A^2}{45 - A} = 900$$

$$900A - 20A^2 + 45A^2 = 900\ (45 - A)$$

$$180A - 4A^2 + 9A^2 = 8100 - 180A$$

$$5A^2 + 360A = 8100$$

$$A^2 + 72A = 1620$$

$$A^2 + 72A + 1296 = 2916$$

$$A + 36 = \pm 54$$

$$A = 18 \text{ mi. per hr.}$$

(4) $120 + 15B = 300$

$$15B = 180$$

$$B = 12 \text{ mi. per hr.}$$

$$X = \frac{300}{30} = 10 \text{ hr.}$$

Chicago, Ill. JOHN SCHROEDER.

Editor's Note: For another algebraic solution see p. 696 of the June 15 issue.

Problems in Electric Motors and Generators*

6. WHAT WOULD BE the result of having one field coil reversed in a dynamo or in a motor?

7. To what are core-loss, field-loss, and armature-loss due?

8. Why should not copper brushes be used on high

*Continued from page 753, July 1 issue.

voltage dynamos which are subject to sudden changes of the load—changes that cannot be met by shifting the brushes?

9. How are synchronous motors generally started?

10. The input of a dynamo is 20 hp. and the output is 12½ kw. What is the efficiency?

11. What is the result of continually overloading a dynamo?

12. Describe a method of locating a short-circuited armature coil.

13. What is the purpose of the commutator on a dynamo? C. B. S.

A. 6. With one reversed field coil in a generator or motor, the effect is the same as that brought about by the loss of two coils, the field resistance and current remaining unchanged. In a generator, this would cause a reduction in generated voltage; in a shunt motor, an increase in speed.

7. a. The core loss is composed of two elements, the hysteresis loss and the eddy current loss. The hysteresis loss is due to the fact that when a magnetizing force is applied to a body, there is a distinct lag between this force and the magnetization of the body. This is attributed to molecular friction. The energy required to alternately reverse the molecules in a body when an alternating magnetizing force is applied constitutes the hysteresis loss. The eddy current loss is due simply to the heating effect of the currents induced in the core by the alternating flux.

7. b. The field loss is due to the heating effect of the current in the field circuit of a generator or motor. The field takes a current I_f at the terminal voltage V of the generator or motor. Therefore, the power loss in the field, including the rheostat is $P_f = VI_f$.

The armature loss represents the power required in overcoming the resistance of the armature winding brushes and commutator. It is expressed by $P_a = I_a^2R_a$, in which P_a is the armature loss, I_a the armature current and R_a the armature resistance measured between the terminals of the machine.

8. Copper brushes should not be used on high voltage machines subject to fluctuating loads due to their low resistance. Under fluctuating loads there is a shifting of the plane of commutation causing currents of self induction in the armature coils to pass between commutator segments short circuited by the brushes. Because of the low contact resistance of copper brushes, these currents are likely to cause severe sparking with consequent pitting of the commutator.

9. Any polyphase synchronous motor may be started by applying full load voltage to the armature, leaving the field open until the motor has reached normal speed. This method, because of the heavy starting currents required, is not desirable. To limit the starting current, auto starters or compensators are often used, but this arrangement does not provide great starting torque, so most modern synchronous motors are provided with a special auxiliary winding similar to the winding on the rotor of a squirrel induction motor. Besides improving the starting torque, this squirrel cage winding also has a tendency to reduce shunting.

10. The efficiency of a generator is the ratio of the electrical power delivered to the mechanical power received by it. In other words, it is the output divided by the input. In this case it is calculated as follows:

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{12.5 \times 1000}{20 \times 746} = \frac{12{,}500}{14{,}920} =$$

83.8 per cent.

11. As is the case with any other electrical device, the result of continually overloading a generator is its destruction. The constant overheating will gradually char the insulation, resulting sooner or later in a short circuit or ground.

12. As soon as an armature coil becomes short circuited the machine should be shut down and if an inspection can be made immediately, the short circuited coil can be determined by noting with the hand which conductor has the highest temperature. If this method fails to reveal the damaged coil, the bar to bar test may be used.

Figure 2 shows the connections necessary for a test of this kind. The stated current, taken from the 110-v. circuit, should be sent over the armature at opposite

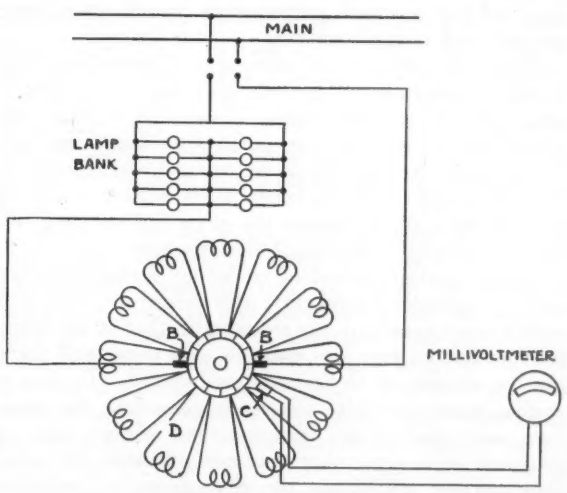


FIG. 2. CONNECTIONS FOR TESTING OUT ARMATURE COILS WITH A MILLIVOLTMETER

sides of the commutator. The brushes, b, should only be wide enough to cover one bar. c is a fibre block holding the copper contact points so spaced as to rest on adjoining segments as shown. Adjust the lamp bank until the flow meter gives a readable deflection when c is in contact with what are supposed to be good coils. The deflection of the voltmeter will depend upon the difference of potential between the bars. If everything is all right, practically the same deflection will be obtained all around the commutator, regardless of what pair of bars c may rest upon. Place the contact points over each pair of bars and note the deflection on the flow meter. When the short circuited coil to which the bars are connected comes under the contacts, there will be little if any movement of the needle, because there will be little or no drop through the coil.

13. The purpose of a commutator on a direct current generator is to rectify the alternating current induced in the armature.

EDITORIAL COMMENT

Power Records and Costs

Time was when merchants kept no books; they did not trouble themselves with keeping costs; they kept their accounts "in their heads." Those were the "good old times"—for those who could thus avoid paying. We are glad they are "old" and that we have long passed them.

Without adequate records and accurate cost analysis no business can be successfully run today. Large central stations have already been provided with record and cost systems, but owners of small power plants, especially those connected with industrial plants, are not yet sold on the idea that thorough analysis of power costs pays and that adequate performance records are a necessary adjunct to such analyses.

Waste is reduced and efficiency of operation raised by the maintenance of records that are freely open to inspection by all concerned. Especially is this true where several persons are performing the same task. In this case, competition is set up and work takes the form of a game. Instinctively all who have red blood in their veins enjoy playing the game and entering into friendly rivalry with their fellow workers.

The graphical method of recording performance records is especially useful. By this means not only may each operator compare his record with that of his fellow workers but he may also note his own trend and therefore be stimulated to beat his own record. Devices of various kinds for quite accurately recording the conditions and flow of all materials and energy used or produced by a power plant, are now available, but many plant owners still doubt the advisability of installing accurate measuring and recording devices and methods.

Manufacturing industries have naturally led other industries whose functions are not directly those of manufacturing, in completeness of organization and contol, in thoroughness of record keeping, in the establishment of incentives for workers, hence in the reduction of wastes. Perfecting the efficient production side of the power plant has lagged behind the perfecting of manufacturing processes because the industrial plant owner has regarded his power plant only as an accessory to what he has viewed as his primary project. He is losing much by accepting this premise. Power represents about two to three per cent of the manufacturing cost. It is usually possible to save at least 30 per cent of the power cost by more efficient operation as a result of the maintenance of adequate records and of proper analysis of these records. This saving would reduce the manufacturing cost about one per cent. If the manufacturing profit is only four or five per cent, by adding this one per cent, the proportionate gain would obviously be great.

In a few years, the method of operating a power plant "in one's head" will be as obsolete as is candle lighting in the home. The principle of the survival of the fittest will have found the "record in the head" plant proprietor so far behind in his struggle for a foothold on the slippery path of power that it will require the use of a Zeiss binocular to bring him even into the field of vision.

Methods of reducing material costs may be determined by analysis of adequate records, but methods of providing for the constant and complete carrying out of perfected methods requires also the enlistment of favorable human behavior. All men are most interested in their work when they are working for themselves. The nearer we can approach this direct vital interest, the more completely can we utilize the time of employes and enlist their active good will. If a man has a chance to do better for himself when he works harder, by receiving an extra reward, if the reward is a fair one, he will work harder and think more fruitfully. This is a natural, instinctive response, which is experienced by all men. The methods indicated above through the establishment of adequate records, make possible not only the creation of incentives for the more efficient operators of power plants but also the provision of a performance yard stick which will enable power plant owners to realize that they cannot afford to employ cheap operators.

Flood Control with Power Generation

As a result of the recent Mississippi River floods, considerable interest has been aroused throughout the country in the subject of flood control on the Mississippi and its tributaries. Discussion of flood control on the Colorado and particularly of the Swing-Johnson bill has also been nation-wide. In these discussions it has been taken as a matter of course that gigantic water power developments in connection with the flood control works would be included. While the flood control projects themselves are clearly matters for the Federal government to handle in co-operation with the various states, power development may or may not be justified in connection with them, depending on the conditions. It has often been pointed out that the attempt to force the government into the power business usually militates against the most economical generation of power. It would seem that water power made available by flood control works or by great irrigation projects can best be developed by some co-operative scheme, in which a power company would be responsible only for the power development and a public works agency responsible only for the control of the flow of water.

Such schemes have recently been worked out by a large western public utility co-operating with two irrigation districts. One of these schemes, the Melones project, is described elsewhere in this issue. Under the terms of a recent agreement, the money paid by the

power company to the irrigation district has proved of material assistance in financing the building of the irrigation works. The irrigation district built the dam and irrigation works and sells the impounded water to the power company. After the latter has used it for power generation in the Melones power plant, which it built below the dam, the water flows on to the irrigation users.

In this way each job is done effectively. It would have taken the power company a long time to learn the irrigation business thoroughly; conversely, it would have taken the irrigation district a still longer time to learn as much about power generation as the utility already knows. A co-operative agreement, however, solves many problems for both.

Obstacles to similar schemes in various parts of the country are mostly political and mental rather than engineering. That they can be surmounted with benefit both to the general public and to the power companies, is well illustrated by the successful completion of the Melones project.

Off Duty

Way back in the stone age, in the year 7,984,312 B. C. to be exact, Willie Marblehead sat in the back yard of his bungalow in Little Rock, resting after a hard day at the office. For Willie was tired, having just chiseled a 3-ton love letter to his Sheba. Now, at peace with the world, in the cool of the evening he sat stroking the soft fur of Halitosis, his pet sabre tooth tiger who lay at his feet. Suddenly, the stillness was shattered by a fearful yowl, and without warning Halitosis playfully sank a couple of her sabre teeth into Willie's leg. Naturally Willie became angry—such ungratefulness could not be tolerated from the best of cats and so with his other foot, his good one, he kicked Halitosis for a row of Italian marble postage stamps. "You damn kat," he growled, as pussy disappeared over the horizon, "let this teach you a lesson."

But there's a reason for everything, and in this instance, although unknown to Mr. Marblehead or to Halitosis, the cause of the disturbance was a diabolical force called electricity. When Willie stroked Halitosis' fur it had become electrified and as the charge accumulated, a spark had passed between Halitosis' nose and Willie's leg. Willie had felt the sting of the spark and so had little sabre-tooth but neither knew what had happened. So it remained a mystery.

To this day, no one knows what electricity is, that is, it is taken for granted that no one knows what it is. Ask anybody who discovered electricity and they will answer quick enough, "Benjamin Franklin, of course," but ask them what it is and they will shake their heads mysteriously and say "Nobody knows."

In view of known facts this attitude on the part of the general public is not quite fair, for we *do* know what electricity is, just as much as we know what anything is. In fact, we know more about electricity than we do about almost anything else, and as explained in an Off Duty article several months ago, we have reached the point where it becomes necessary to explain all other phenomena in terms of electricity. The basis of all phenomena seems to be electrical and whether we start with chemistry or biology or optics, finally we come to a point where things can only be explained in terms of the electron. True, in our investigations of the electron, we ultimately reach a point where we cannot explain any further, but this applies to all things. All human knowledge is bounded on all sides by the unknowable.

To the world at large, however, electricity is still the strange mystery it was when Willie Marblehead electrified Halitosis' fur and created the first man-made lightning. The average person regards it as an absolute mystery and even though the nature of the electron and its action is explained to him, he remains suspicious and still insists that nobody knows anything about it. But Franklin discovered it—with his kite.

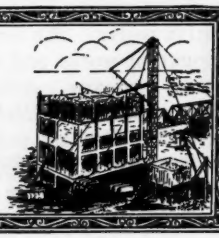
Certain things are accepted not because people think them out for themselves, but because someone has said so before. In the same way that Mr. Average Man knows that Franklin discovered electricity, he knows that Marconi invented wireless, that the Einstein theory can be understood by only 12 men in the world, that if all the water power sites were developed all the steam stations could be shut down, that radio today is in its infancy, that electricity is in its infancy, that, where there is a fire, it started due to crossed electric wires, that smoke consumers installed in every smoke-stack would overcome the smoke nuisance in cities, that an aviator flying over the ocean can fly upside down without being aware of it, that a steel skyscraper could be demolished by playing a certain note on a violin, that the Einstein theory is a lot of nonsense, that Edison sleeps only 5 hours out of 24 and works the other 19, that Steinmetz calculated a complete table of logarithms in the woods, and that Edison invented moving pictures.

In his American Credo, George Jean Nathan has listed over 1200 things which the average American believes and accepts as true. If any of the foregoing relating to scientific and engineering matters are not included, they ought to be for they form part of the common belief. There are, no doubt, many others but these taken at random are typical. The older they become the more firmly are they adhered to. Electricity was in its infancy in Willie Marblehead's time. Today, in the year 1927, A. D., it is still in its infancy, and if human nature doesn't change greatly in the next million or two years it will be in its infancy in the year 7,346,902, A. D.

By that time the 12 men who understood the Einstein theory today will have died, but there will be 12 new ones to take their places. As for poor Tom Edison, we don't know what will become of him. The amount of sleep he gets has been steadily decreasing and it looks as though by that time he will have to work 28 out of the 24. The public is heartless.

ALL THE CRASHES of lightning at any given time in the world produce power equal to less than one-twentieth of the amount being generated by the light and power companies in the United States, according to computations based on estimates of F. W. Peek, Jr., consulting engineer for the General Electric Co. There is an average of 1800 thunderstorms in progress in the world at any one instant, according to Mr. Peek. These give 300,000 flashes per hour, each of about 4 kw-hr. power capacity, and make a total power capacity of 1,500,000 hp. operating continuously. This is compared with the 32,500,000 hp. capacity of generating stations in the United States.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Cinder Eliminating Fan Employs Conoidal Rotor

ELIMINATION OF CINDERS from the stack discharge of power plants has become a question of vital importance to many power plant engineers not only when the plants are installed in residential sec-

CINDER ELIMINATING FAN OF 80,000-C.F.M. CAPACITY, WITH FRONT OF CASING REMOVED TO SHOW LOUVRE OPENINGS

tions, but also in many industrial power plants where cinders and dust discharged from the stack might destroy or reduce the value of the manufactured product. For control of cinders in such cases, the Buffalo cinder-eliminating fan shown in the accompanying illustration has been developed. This is most applicable as an induced draft fan.

The principal feature of this new fan is that it employs a rotor of the standard Duplex and Turbo conoidal fan type as manufactured by this company, in combination with a special design of casing incorporating special baffles and louvres to eliminate the solids in the gas, depositing them in an air-tight hopper. The use of a standard type of fan rotor is intended to produce high air handling efficiency and it is stated that this efficiency is only about 5 per cent lower than that of the best designed forced or induced draft units.

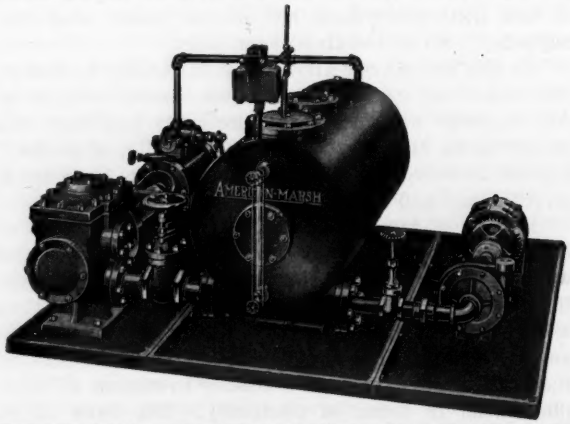
Test results from one of these cinder eliminating induced draft fans showed that the material removed from the gas represented approximately 95 per cent of the total solids contained in it. Of this amount 5.5 per cent passed through 200 mesh and 71.4 per cent passed through 40 mesh screen with varying amounts between these two figures.

Standard rotors of these fans are designed for great rigidity with double curvature of the conoidal fan blades. Since the blades are not of special construction for catching solids, it is stated that this design lessens the possibility of the rotor becoming unbalanced. The entire unit is designed with large passages to eliminate the possibility of clogging. Housings are of heavy rolled steel plate with suitable angle iron bracing. A section of the housing is removable for interior inspection and the inlet cones are removable so that shaft and rotors can be taken out without dismantling the housing. For the high bearing pressures involved in mechanical draft installations, special bearings and pedestals are furnished. The bearing is of the babbited type with ball and socket iron-to-iron alining feature. Water-cooled bearings of modern design are furnished where high gas temperatures are involved.

The Buffalo cinder eliminating fan is being placed on the market by Buffalo Forge Co., Buffalo, N. Y.

Day and Night Condensation Pumps for Heating Plants

IN MANY HEATING PLANTS a comparatively high steam pressure is carried during the day, sufficient to operate a steam pump for feeding the boiler, while at night the steam pressure is allowed to drop to only a



SIMPLEX PUMP, CENTRIFUGAL PUMP, AND RECEIVER TANK WITH AUTOMATIC CONTROL EQUIPMENT ARE ALL MOUNTED ON HEAVY CAST-IRON DRIP PAN

few pounds gage and sometimes even to zero. In this case, any condensation returning from the heating system could not be put back into the boiler because the steam pressure would be too low to operate by the steam pump. Consequently there is a possibility that the receiver tank and the return lines might become flooded during the night and that it would require considerable time in the morning before the steam pressure could be raised sufficiently to operate the steam pump and clear these lines.

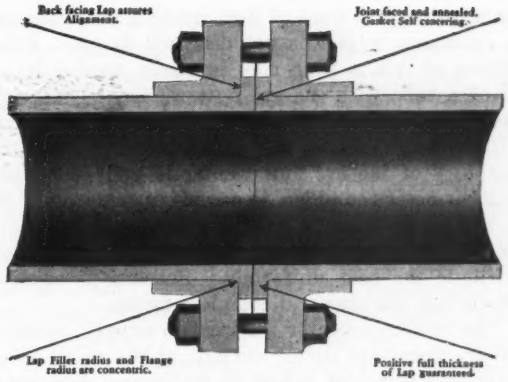
To obviate this difficulty, therefore, the American Steam Pump Co., Battle Creek, Mich., has developed the American-Marsh Day and Night Condensation Pump. This unit consists of a reciprocating steam pump, a motor-driven centrifugal pump and a receiver tank all made up as one unit. It is controlled by automatic methods in such a way that the steam pump operates as long as there is sufficient steam pressure available, say to a minimum of 15 lb. gage, and when the steam pump stops operating the centrifugal pump automatically starts and keeps the return lines free of condensation until sufficient steam pressure is again generated to operate the steam pump.

Automatic control is provided by two float switches located in the receiver tank. These floats are at different levels, the lower float operating the steam pump and the upper float controlling the motor-driven centrifugal pump. It is obvious that when the steam pump ceases to operate the water rises in the tank, thus drawing into service the motor-driven centrifugal pump. This unit is not intended to create a vacuum and should be installed low enough so that all returns flow into the tank by gravity.

The steam pump is of the simplex type, fully bronze fitted with water valves of hard rubber. To insure perfect alinement, a heavy cast iron cradle yoke is furnished between steam and water cylinders with ring and plug fit. The centrifugal pump is of the side suction closed runner type, with removable volute. The extra deep stuffing box is furnished with grease cup lubrication and a flexible coupling is provided between pump and motor, together with suitable thrust collars. The receiver tank is of cast iron with clean-out opening at end and vent opening. A water glass is included as standard equipment. The automatic steam control valve at the end of the tank consists of an ingenious semi-rotative balanced valve, designed so that it will wear to a perfect seat. The float is of seamless copper balls. The centrifugal pump has a double pole float switch mounted on the top of the tank. These units are made in nine sizes to drain radiation surfaces from 3000 sq. ft. up to 75,000 sq. ft.

Navco No. 4-6-9 Pipe Joint

DESIGNED ESPECIALLY for high steam pressures and temperatures, a new type of pipe joint is now being manufactured by the National Valve & Manufacturing Co., Pittsburgh, Pa. It includes many of the features embraced by the well known Van-Stone joint in addition to recent improvements. The outstanding feature of this joint, known as the No. 4-6-9 joint and shown in the accompanying illustration, is the back facing of the lap designed to insure perfect alinement. After facing both back and front, a lap of positive full pipe thickness is obtained. The radius of the flange and the lap fillet radius are concentric. Only a minimum clearance is allowed between the pipe and the flange, just enough to permit the moving of the flange. The entire joint is annealed to relieve any strain which may have set up during the course of manufacture. Installation includes simply inserting a self-centering gasket and pulling up the bolts, while dismantling is accomplished just as readily.

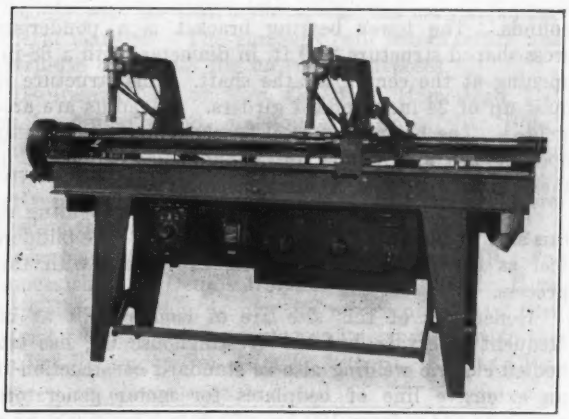

Back facing Lap assures Aligament.
Joint faced and annealed. Gasket Self centering.
Lap Fillet radius and Flange radius are concentric.
Positive full thickness of Lap guaranteed.

SECTION SHOWING BACK FACING OF LAP OF NEW JOINT

New Butt Welding Machine Uses Carbon Arc Process

AMONG THE MANY types of welding equipment which have been brought out in recent months, the automatic machines for electric arc welding have aroused considerable interest. It was only a few years ago that everyone was agreed that electric arc welding would forever remain a manual process in which the skill of the operator would be the limiting factor. Yet, in the last 12 mo., numerous new machines have appeared on the market for doing welding by machine which had formerly been done by hand.

The Lincoln butt welding machine, illustrated herewith, is a further development of the machine-driven carbon arc to solve the problems of welding. One ordinarily thinks of butt welding in terms of the resistance welder. The arc butt welder is not an alternative method of doing butt welding but is claimed to



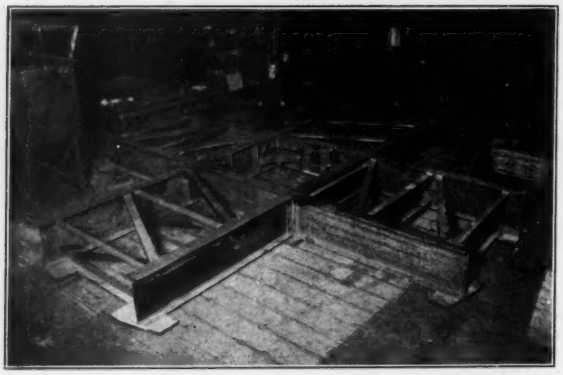
BUTT WELDER WITH TWO AUTOMATIC HEADS

be a solution to a class of butt welding problems which the resistance welder is not designed to solve. As an instance of this, a plug may be easily welded into the end of a tube with the arc butt welder. The machine illustrated welds both ends of the tube at once by use of the two automatic heads. A similar instance of applicability of the arc butt welder is that of welding a small diameter round bar to a large diameter bar. With the arc butt welder, the welding heat is applied to the joint by the carbon arc and the bars are revolved to distribute the heat uniformly. Pressure is applied to squeeze out the slag and complete fusion.

The motor-generator set used to supply current for the arc furnishes direct current at 40 to 60 v. The motor is a standard induction motor and does not take a special power rate. The unit is being marketed by The Lincoln Electric Co., Cleveland, Ohio.

Arc Welding Used in Building Generator Bearing Bracket

MANY NEW APPLICATIONS of the electrical arc welding process are being made these days, a most impressive example being shown in the accompanying illustration. This is a 16,000-lb. lower bearing



LARGE LOWER BRACKET OF 40,000-KV.A. CONOWINGO GENERATOR. ALL JOINTS ELECTRICALLY ARC-WELDED

bracket, made by the Westinghouse Electric and Manufacturing Co., for the large Conowingo waterwheel generators. Each of these three 40,000-kv.a. vertical machines is 37 ft. in diameter, and weighs over one million pounds. The lower bearing bracket is a ponderous cross-shaped structure 24.9 ft. in diameter, with a 68-in. opening at the center for the shaft. This structure is built up of 24-in. standard girders. All joints are arc-welded. The heavy cast steel brackets about the center opening are also welded on, round holes being cut in them to give greater welding periphery.

This is one of the heaviest examples of welding of this sort to date and indicates the confidence the builders feel as the result of their long experience with this process.

Generators of this size are of course built at infrequent intervals, but the Westinghouse Co. has embodied electric welding also as standard construction in an extensive line of bedplates for motor generators, ranging in size from 100 hp. (75 kv.a.) to 25,000 kv.a. As will be seen, welding allows a neat and strong design of bedplate, the heavy H-beams used being ideally adapted for grouting to the foundation. As in other examples of electric welded design, there is a very material saving in weight.

Automatic Pipe Cutter for 2-Inch to 4-Inch Pipe

FOR CUTTING 2-in. to 4-in. pipe, the new Toledo automatic pipe cutter has just been put on the market by The Toledo Pipe Threading Machine Co., Toledo, Ohio. Its construction is shown in the accompanying illustration. It weighs 65 lb. and is designed for simplicity and ease of handling. It is designed to leave a

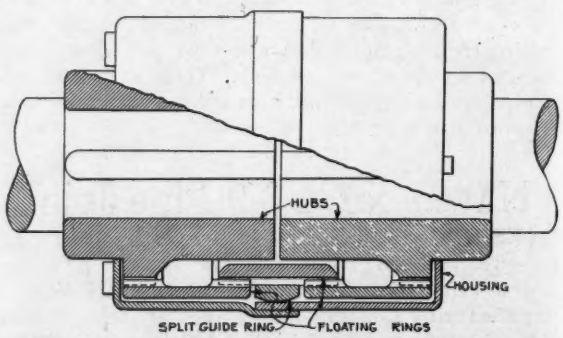
NEW AUTOMATIC PIPE CUTTER

straight, square-end cut with no inside burr and with the outer edge chamfered to make it easy to start threading dies on the pipe.

Knives are fed automatically, a single hand wheel being provided to set them for cutting or to return them quickly after the pipe is cut and there is only one jaw to center the tool on the pipe. The cutter is designed to be operated anywhere, either with the regular ratchet handle furnished with Toledo threading tools or with a Toledo power drive. With the latter, it is claimed that the new cutter will cut a 2-in. pipe in 20 sec. and a 4-in. pipe in 65 sec.

Dahlstrand Coupling Re-Designed

IN THE January 15, 1927 issue appeared a description of a new flexible coupling developed by J. Y. Dahlstrand, Wellsville, N. Y. This coupling consists essentially of two hubs, one on each of the shafts, con-



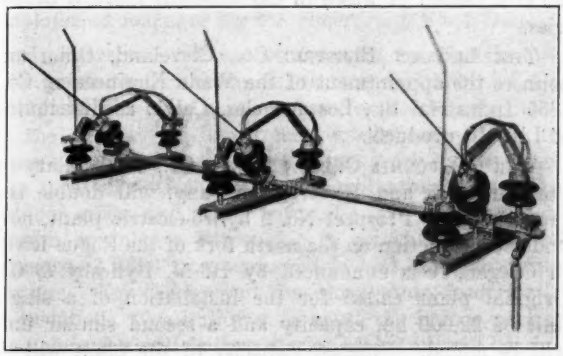
CLAWS ON FLOATING MEMBERS ENGAGE WITH CLAWS ON HUBS

nected by floating rings having toothed claws on inner and outer circumferences and interposed radially between the hubs so that the claws will engage with claws

on the hubs. This design has now been modified somewhat, as shown by the accompanying sketch, although the fundamental idea of the coupling remains the same. In the second form, three or more floating sleeves equipped with claws are interposed between the hubs, the claws engaging as shown. These members are not connected by dowels, bolts, or pins and the design is intended to make the flexibility of the coupling dependent on the compressibility of the oil film between the claws and upon the mechanical arrangement of the sleeves. The form of coupling shown here is the one that is now being marketed.

New Westinghouse Disconnecting Switches

WESTINGHOUSE ELECTRIC & Manufacturing Co. has recently placed on the market a new line of air-break disconnecting switches, that are gang operated and are for outdoor service. These switches may be operated as single, double or three-pole units and are available for voltages of 7500, 15,000, 25,000, 37,000, 50,000 and 73,000, in capacities of 400 to 600 amp. A



NEW RW AIR-BREAK DISCONNECTING SWITCH MANUFACTURED BY THE WESTINGHOUSE ELECTRIC AND MANUFACTURING CO.

200-amp. rating is also available for the 7500 and 15,000 v.

Ease of installation and operation, and ruggedness of construction are the outstanding features of these new switches. The contact fingers on these switches are of the self-closing type and have ample contact surface. Arcing horns are furnished with all upright mounted switches, but if not required may be discarded. The switches are also furnished for inverted and vertical base mounting. The operating mechanism is of the double toggle type, with arrangement for padlocking in both positions.

Iowa and Illinois N. A. S. E. Joint Meeting

A THREE-DAY joint session of the Iowa and Illinois Associations of the National Association of Stationary Engineers was held at Rock Island, Ill., June 22-24, with nearly 400 delegates and exhibitors attending. Programs were acclaimed by the engineers as among the finest their units had ever provided. W. L. Rhoades, Decatur, Ill., was paid high tribute by the Illinois branch, which broke precedent of many years' standing to re-elect him as president. Other officers of the Illinois Association are: Enid E. Winholt, Moline, vice-president; W. L. Hamilton, Decatur, secretary-treasurer; H. E. Hintz, Moline, conductor; L. M. Haldey, Springfield, doorkeeper. Mr. Rhoades received a past president's badge after announcement of his re-election was made, F. W. Raven, Chicago, secretary of the National Association, making the presentation.

W. A. Pike, Marshalltown, was elected president of the Iowa State Association; L. T. Hazelwood, Des Moines, vice-president; C. A. Bland, Des Moines, secretary (re-elected); J. A. Coulson, Sioux City, treasurer; H. O. Grimes, Marshalltown, conductor; R. C. Larson, Ottumwa, doorkeeper; W. W. Winger, Ottumwa, state deputy.

Dr. B. J. Palmer of the Palmer School of Chiropractic was principal speaker at the annual banquet at which Mr. Raven presided. Speakers at the joint sessions were Royal H. Holbrook, Iowa State College, Ames, past president of the National Association; H. R. Williams, manager of the service department of the Garratt-Gallahan Co., Chicago; H. A. Kleinman, Moline, People's Power Co., and John W. Drabelle, Cedar Rapids.

Fifty booths were occupied by exhibitors and the visitors were escorted on tours of the Riverside Government arsenal and Sear water power plants, Bettendorf shops and other industrial centers of the community.

News Notes

GEORGE B. CORTELYOU, President of the Consolidated Gas Co., of New York has been elected Chairman of the Joint Committee of National Utility Associations, representing the gas, electric and street railway industries of the U. S., according to announcement by the association. Philip H. Gadsden, vice-president of the United Gas Improvement Co. of Philadelphia, was elected vice-chairman and chairman of the Executive Committee. Stephen Davis, formerly judge of the Supreme Court of New Mexico and Solicitor of the Dept. of Commerce, has been appointed counsel of the committee.

CONGRESS OIL CO., with general sales office at 396 Broadway, New York and compounding and blending plant at Rahway, N. J., has been organized by L. Cuervo Munis and A. L. Nugey. Robert R. Stephens, formerly with the Gulf Refining Co., has been appointed general manager. The company will manufacture and distribute lubricants for universal purposes.

HOMESTEAD VALVE MFG. CO., INC., Homestead, Pa., has appointed M. S. Maleson, 442 Rockefeller Bldg., Cleveland, Ohio, as exclusive sales representative in the Cleveland territory. Fred W. Layman, who was formerly in charge of the Cleveland district sales, is now covering the far western states for the company.

GRINDLE FUEL EQUIPMENT CO., Harvey, Ill., announces that the Dennis Engineering Co., 243 N. High St., Columbus, Ohio, is now its representative in that district. It has also appointed as its representative the Burdick-Pensinger Co., 3409 E. 18th St., Kansas City, Mo.

LINK-BELT CO., Chicago, Ill., anonunces the appointment of R. P. Shimmin as assistant to the chairman and

the president with headquarters at 910 S. Michigan Ave., and Frank B. Caldwell as Sales Manager with headquarters at 300 W. Pershing Road, Chicago.

American Engineering Co., Philadelphia, Pa., announces an addition to its line of Lo-Hed hoists, in the form of a motor trolley electric monorail hoist designed to operate in 15½ in. headroom. This hoist is built in half ton and ton sizes and is similar in construction to the standard Class A Lo-Hed hoist, except that it is mounted on an 8-wheel trolley that reduces the headroom requirement by more than 5 in.

Remote control of both hoist and trolley motors can be provided. A ball bearing motor is used and gear shaft and trolley wheels are fitted with Hyatt roller bearings. The drive between motor and drum is of the spur gear type and runs in oil. Alemite lubrication is provided on all bearings not automatically lubricated by the oil bath. Hoist is made for operation with alternating current at 20 f.p.m. or with direct current at 20 to 40 f.p.m., and a special high-speed hoist provides for double this speed if necessary.

C. O. Bartlett & Snow Co., Cleveland, Ohio, has established a district office at 406 Bessemer Bldg., Pittsburgh, Pa., in charge of W. C. Schade.

The Climax Engineering Co., Clinton, Iowa, announces the appointment of the James McGraw Co., Richmond, Va., as its sales agents in Richmond and vicinity.

C. W. Sullivan, 621 Washington Blvd., Chicago, Ill., is direct factory representative of Leslie Co., Lyndhurst, N. J., for sale of Leslie Pressure Regulators in the Chicago district, in place of O. C. Keckley Co.

The Brown Instrument Co., Philadelphia, Pa., has just opened a midwestern repair and service station under the name of The Brown Instrument Company Service Station at 217 E. Illinois St., Chicago, Ill., phone Superior 6615.

Stevens & Wood, Inc., 120 Broadway, N. Y., announces the opening of an office at 53 W. Jackson Blvd., Chicago, in charge of Lucien I. Yeomans. The company has also been retained by the Board of Transportation, New York City, to make a complete study, investigation and report on the method to be adopted to provide electric power for the new municipally-owned rapid transit lines.

The Foos Engine Co., Springfield, Ohio, calls attention to the change in its name, which was formerly The Foos Gas Engine Co. It also announces the election of J. F. Baker as president of the company, M. E. Baker as secretary-treasurer, R. C. Burrus as sales manager, W. W. Schettler as chief engineer and Geo. F. Noltein as mechanical engineer. It has appointed Garvey & Palmer, Inc. as its Pacific Coast representative with offices in Los Angeles, San Francisco and Seattle.

Stone & Webster, Inc., is now making additions to the plant of El Paso Electric Co., El Paso, Texas, to consist of one B. & W. 1066-hp. water tube boiler with air preheater and superheater, designed to operate ultimately at 400 lb. pressure and to be equipped with Green chain grate stokers and hydraulically-operated ash gates. A Stephens-Adamson Mfg. Co. coal conveyor and necessary auxiliaries are being installed. J. B. White is superintendent for Stone & Webster, Inc., and J. U. Morris is master mechanic on construction. A. C. Learmonth is chief engineer of plant and H. I. Wambeam is chief electrical engineer.

Announcement is made that Aubrey J. Grindle has established the Pulverized Fuel Equipment Co. with office at 1238 Builders' Bldg., Chicago, Ill., for the manufacture and sale of powdered coal burning equipment. Mr. Grindle was recently a director and vice-president of the Grindle Fuel Equipment Co., of Harvey, Ill., subsidiary of Whiting Corp., but except for a very small amount of the total outstanding stock, Mr. Grindle has severed his connections with this company entirely, and there is no connection whatever between the two companies. It is also stated that the Pulverized Fuel Equipment Co. is not purchasing any equipment manufactured for or by the original company.

Arno C. Fieldner, superintendent of the Pittsburgh experiment station of the United States Bureau of Mines, Department of Commerce, has been appointed Chief Engineer, Division of Experiment Stations of the Bureau, effective July 1. In his new position, Mr. Fieldner will correlate the scientific activities of the Bureau's experiment stations, which are now studying the elimination of waste in the different mineral industries.

The Lincoln Electric Co., Cleveland, Ohio, announces the appointment of the Wade Engineering Co., 1855 Industrial St., Los Angeles, Calif., as distributor of Lincoln products.

The California Oregon Power Co., a subsidiary of Standard Gas and Electric Company, will double the capacity of its Prospect No. 2 hydro-electric plant, now under construction on the north fork of the Rogue River in Oregon, it is announced by H. M. Byllesby & Co. Original plans called for the installation of a single unit of 22,000 hp. capacity and a second similar unit will be added. Ultimate capacity of the plant will be 66,000 hp. It is expected to be ready for operation by October first.

The Central Service Co. at Des Moines, Ia. is building a new raw water motor-driven ice plant at Ft. Dodge, Ia. Two 60-t. York ice machines are being installed, and the company is also building a 500-t. storage plant which will later be increased to a capacity of 5000 or 6000 t. It is expected that the new plant will be finished by August 1. It will be known as the Ft. Dodge Ice Co.

The Texas-Louisiana Power Co., Silver City, New Mexico, has just completed work of installing one 600-hp. DeLaVergne Diesel engine, which is the second unit of this type added to the plant this year. Also, one 15-t. DeLaVergne ice machine was included in this last work. H. Zier, construction engineer of the DeLaVergne Machine Co., superintended the work. A. I. Murray is general manager of the Silver City district for the Texas-Louisiana Power Co., and J. R. Poindexter is chief engineer.

At Tucson, Arizona, there is being installed by Sanderson & Porter, consulting engineers, New York City, for Tucson Gas, Electric Light & Power Co., a 3750-hp. Busch-Sulzer Diesel engine, which, when on the line, will make the Tucson plant the largest Diesel engine public utility plant in the United States. The units

are: 2 Werkspoor, 1000 hp. each; 2 Busch-Sulzer, 520 hp. each; 2 Fulton, 500 hp. each; 1 Busch-Sulzer, 3750 hp. In addition there is steam capacity to generate about 700 kw.

M. A. Pooler is general manager, R. V. Sanford superintendent of distribution, and E. E. Johnson is chief operating engineer of the Tucson Gas, Light & Power Co. R. V. Rosenbaum, construction engineer of Sanderson & Porter, is superintending work of installing the new unit.

THE AMERICAN ELECTRIC SWITCH CORP., Minerva, Ohio, has been organized for the manufacture of a line of safety switches, fuse panels, switch boards and panel boards for all power plant and industrial uses. J. C. Lewis is president, Arthur Koch, treasurer and E. F. Rinoehl secretary.

JOHN M. GOODELL, formerly editor of Engineering News and Engineering Record, and recently editor of The Journal of the American Water Works Association and in charge of publicity for Babcock & Wilcox, died on June 22 at New York. Mr. Goodell was a graduate of Worcester Polytechnic Institute and, besides his editorial work, had engaged in paper mill construction, highway construction and, during the World War, was employment manager for the Emergency Fleet Corp.

TO MEET THE INCREASING demands for electric light and power in Princeton, N. J., the Electric and Gas Company will build a new substation on Wiggin Street in the vicinity of its present substation. Plans are being prepared but no date to start work has been set. The new substation will be a combination indoor and outdoor affair, and of the automatic type with the high-tension equipment outdoors. It will have an initial capacity of 3800 kv.a. arranged in two banks of transformers. For the present five three-phase feeders will be installed. The building to house the indoor part of the substation will be two stories high and will be constructed of brick and steel, with tapestry face brick and limestone trim.

THE WALSH & WEIDNER BOILER CO., Chattanooga, Tenn., has added to its organization J. Gould Coutant, who will assist manufacturers of fuel burning equipment, air heaters, economizers, etc., and prospective purchasers of boilers with their furnace temperature, boiler gas temperature and heat balance problems. Mr. Coutant will be located at the company's New York office at 11 Broadway.

CHANGES in the district offices of the Lincoln Electric Co. have recently been made as follows: L. P. Henderson, formerly of the Detroit office, has been transferred to Chicago. J. W. Shugars and R. D. Layman of the Cleveland Works have been moved to Detroit. D. H. Carver of Cleveland has gone with the Ohio Service Division at Cincinnati. R. F. Terrill has been transferred from Cleveland to the Eastern Service Division at New York.

THE ST. REGIS PAPER CO., Watertown, N. Y., has concluded negotiations for the purchase of additional shares of common stock of the Northeastern Power Corp., thus giving control of the utility. The Northeastern utility will become closely identified with the Northern New York Utilities, Inc., with headquarters at Watertown.

J. P. MEYENBERG, INC., is completing the installation of a milk condensing plant at Soledad, Calif., where two Walsh & Weidner 150-hp. boilers of Scotch marine type are being installed. These are equipped with Dow boiler feed pumps and Hammel oil burners, together with a Permutit water softener. A Cyclops 5-t. refrigerating unit is also installed. Fred C. Krueckel is plant superintendent and T. C. Manchester is general manager.

THE CITY COMMISSION, Sioux Falls, S. D., has rejected an offer of $180,000 made by the Northern States Power Co., Minneapolis, Minn., for its municipal light and power plant.

AT A RECENT MEETING of the Board of Directors of the Federal Light & Traction Co., 52 William St., New York, John D. Bowles, its chief engineer, was appointed a vice-president.

SOUTHERN ARIZONA POWER CO., Nogales, Ariz., is installing a 500-hp. McIntosh & Seymour Diesel engine to bring its present plant to a total capacity of 1850 hp. Thomas Pitts is general manager, B. Roark is superintendent of electrical distribution and W. V. Redditt is chief engineer.

THE TOWN OF TOMBSTONE, ARIZ., on July 1 began the construction of a municipal light and ice plant by installing two 40-hp. Fairbanks, Morse & Co. semi-Diesel engines, the setting of which will be supervised by Steinfeld & Co., engineering contractors, Tucson, Ariz., who will also handle all electrical and other installation.

THE NEW JERSEY POWER AND LIGHT CO., Dover, N. J., a subsidiary of the General Gas & Electric Corp., is planning the construction of a steam power plant on the Delaware River at Holland, N. J. The plant will operate at a steam pressure of 1350 lb. per sq. in. and will have an initial capacity of 40,000 kw. and an ultimate capacity of 250,000 kw. and will burn powdered coal.

PACKARD MOTOR CAR CO., Detroit, Mich., has begun construction of a new steam power plant at its factory which will include a 6000-kw. steam turbo-generator to operate at 325 lb. pressure and exhaust at 85 lb. together with boilers and the necessary auxiliaries. Wood refuse will be burned under these boilers.

THE PECOS VALLEY POWER & LIGHT CO., recently organized with a capital of $6,000,000, is planning to build a power plant on the Pecos River in the oil field district of western Texas. This plant will burn oil as fuel, will have an initial capacity of 12,000 kw. and will be under the management of Ford, Bacon & Davis, Inc.

ARIZONA EDISON CO., Yuma, Ariz., is installing two 1000-hp. Diesel engine units to generate power for local distribution and thus avoid the transmission of power over 600 mi. of transmission line, as is now necessary.

THE EEL RIVER POWER CO., Indianapolis, Ind., headed by T. R. Mead and John W. Balch, has plans under way for a hydro-electric plant on the Eel River near Cagles Mills, Putnam County, estimated to cost about $2,500,000 with transmission system.

THE ELECTRIC SERVICE CO., Odessa, Texas, has begun the construction of a new steam power plant to have an initial capacity of 10,000 hp. and to supply service to the oil fields in the vicinity of Odessa.

COCHISE UTILITIES CO., Benson, Ariz., has recently added a 12-t. DeLaVergne vertical type ice machine and an 80-can ice plant for making raw-water ice. About

July 1 the town of Benson, Ariz., completed a city-owned water plant using two Byron Jackson centrifugal pumps, power for which will be supplied by the utilities company, of which Henry Schlegel is president and W. F. Wolfe is secretary and treasurer.

THE BROOKLYN EDISON CO., Brooklyn, N. Y., is planning to install in its Hudson Ave. Station a 135,000-hp. steam turbo-generator unit with the necessary auxiliary equipment.

THE GRAND TRUNK RAILWAY TERMINAL & COLD STORAGE CO., Detroit, Mich., organized as a subsidiary of the recently formed Continental Terminals, Inc., Cleveland, Ohio, plans to build a new ice manufacturing and cold storage plant at Detroit. This will include a nine-story building of about 5,000,000 cu. ft., of which about one-half will be used for ice-manufacturing and the remainder for cold storage.

Books and Catalogs

PATENTS. By Roger Sherman Hoar. New York. 224 pages, $4.50.

What a business executive should know about patents stripped of legal phrases and terminology to enable him to make reasonable decisions and co-operate fully with his patent attorney.

Definitions and distinctions of patents, trademarks and copyrights, patentable features, patent office procedure and tactics, foreign patents, the choice of an attorney and the utilization of a search file are some of the subjects covered. Examples are used freely as illustrations and these are simple, well chosen and covered without resort to legal phraseology.

The author's years of experience in this field serve as a background of fact and although the continuity is sometimes interrupted by references to succeeding chapters, the book will prove of interest and value to practically everyone directly or indirectly connected with the engineering industries.

PORTABLE air compressors in various sizes and types of mountings, with a list of the apparatus which each will operate, are illustrated in a circular issued by Ingersoll-Rand Co., 11 Broadway, New York City. There is also shown a pamphlet, "101 Ways to Save Money with Portable Compressors." It can be had by writing to the company.

GRAVER CORP., East Chicago, Ind., in a new 48-page catalog, describes and illustrates bulk storage tanks. List of standardized tank sizes with specifications for all types are given with drawings of bulk station layouts. Details of fittings and structural steel supports are fully described.

LINK-BELT CO., Chicago, Ill., in Book No. 575, entitled "Handling Things—From Where They Are to Where You Want Them," describes and illustrates its complete line of conveying equipment. Photographs of installations show how various types of elevators and conveyors are applied in industry to carry boxes, machine parts, work in process to dryers and ovens, parts for assembling, crates of all kinds and all types of raw material used in industry.

THE BRISTOL CO., Waterbury, Conn., in a recent bulletin No. 358, gives complete instruction for installation and care of Pyrometers. This discusses first of all principles of operation, methods of erecting pyrometers, location of pyrometers, and finally details of the instrument.

YARNALL-WARING CO., Philadelphia, Pa., in a recent bulletin describes and illustrates its complete line of Yarway Blow-Off Valves for all working pressures up to 1350 lb. Description is given of the recently developed Type C seatless valves.

LEEDS & NORTHRUP CO., Philadelphia, Pa., in Bulletin No. 781, describes Electrical CO_2 Meters. This bulletin contains discussion of the process of combustion with interesting charts and diagrams of the relation of the various factors in this process and then describes in detail the Leeds & Northrup CO_2 Meter, which is based on the thermal conductivity principle.

BAILEY METER CO., Cleveland, Ohio, has just issued Bulletin 131 describing a new line of electrically operated fluid meters to indicate, record and integrate the flow of steam, water, air, gas, and other fluids. Meters are designed so that they do not require the use of voltage regulators and the instrument can be located at any distance from the pipe line in which the flow is being measured.

THE BURT MANUFACTURING CO., Akron, Ohio, has recently issued a 40-page well-illustrated bulletin describing its line of Burt Ventilators. These are made for all industrial and commercial services and for any roof conditions. Several types of damper ventilators are described as well as the new type of fan ventilator.

BRAUNFELS STATION of the Comal, Tex. Power Co., among the first plants to burn pulverized lignite in commercial operation, is described in a pamphlet sent out by Combustion Engineering Corp., 200 Madison Ave., New York.

IN A BOOKLET on Modern Manufacturing with a Stable-Arc Welder, the Lincoln Electric Co., P. O. Box 683, Cleveland, Ohio, outlines the theory of arc welding and gives illustrations of recent applications to making steel machine parts, tools, pipes and fixtures, tanks, heavy duty machinery and steel structures. The welder and its use are also described.

WITH VARIOUS new tables introduced, the 20th annual edition of "Metal Statistics" published by the American Metal Market Co., New York, has been published. Complete statistics, providing information generally required by producers, consumers, buyers and sellers of metals are included.

CLEAN DRY STEAM—HOW TO SECURE IT is the title of an illustrated 12-page bulletin just issued by Hagan Corp., Pittsburgh, Pa., describing the new Hagan three-stage centrifugal steam separator. This is designed to be installed outside the boiler and to remove all impurities and moisture from the steam in three stages.

C. J. TAGLIABUE MFG. CO., 18 to 88 Thirty-Third St., Brooklyn, N. Y., has just issued catalog 942 describing the improved Tag-Mono Indicator and Recorder, designed to give a record not only of CO_2 but also of CO. The catalog discusses first what happens in the furnace, shows an interest-chart of losses due to unburned gases in the flue gas and then proceeds to describe the Tag-Mono Recorder in detail.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Full Steam Ahead

Business conditions are being summarized for the first half of 1927 and trends indicated for the balance of the year.

Total financing in the power plant field for the first six months of 1927 is $1,482,931,022 of which $930,-226,022 is for new construction, extension and additions to power generation and distribution equipment, and the balance for general financing and expansions not definitely appropriated for construction.

These figures are taken from Power Plant Engineering's "Business News Service," which is carefully compiled from country-wide investigations by its staff field men, editors and correspondents.

Power plant development continues to run ahead of general prosperity, stimulated by the recognized profitableness of new power plants and equipment that reduce the cost of power generation, by the continually increasing use of power per capita, which is essentially the basis of our national prosperity, and by the natural increase in population.

In a survey of general business conditions, which used as a basis of comparison the five-year period of 1922-1926, it was shown that the large advantages gained in 1926 were maintained for the first three months of 1927. This survey covered sales of electrical energy, cars of freight loaded and money changing hands.

Since the end of the first quarter of 1927 the coal strike has been in effect in part of the soft coal unionized fields and it still continues. In spite of this strike the bureau of mines report for the week ending June 11 showed the highest output record since the beginning of the suspension on April first, while the total production for the year was higher on June 11 than for the corresponding period in any year since 1923.

There is no existing indication that industry as a whole will suffer a set-back from lack of fuel, though the strike is serving to hasten the maturity of plans to provide the necessary equipment to burn coal more efficiently, especially in industrial plants, a movement based on sound principles regardless of threat of shortage.

The principle that no acute financial crisis can arise that will seriously affect sound enterprises since the establishment of the Federal Reserve Banks again has been vindicated by the flurries in the stock market that have occurred since the first of the year which failed to affect national prosperity in any appreciable way.

Indeed the time is past when any great importance is placed by business men in general upon turbulent conditions in the stock market or in political affairs.

Prosperity continues and cannot help but continue for every enterprise engaged in giving a real fundamental service to the people on an efficient basis.

For the same reasons inefficiency and unsound methods, always a tax on all the people, yearly become less prevalent.

Primarily the American people have become used to prosperity, and its control has passed into their hands. This has made it forever impossible for any man or small body of men to stop or stay the basic factors of prosperity.

Though the people as a whole move slowly, their vastly increased consciousness of economic conditions has made public opinion the great dominating factor in American life.

In a thousand ways, by the printed word, by wire and wireless communication, the public gets the facts with a speed and completeness scarcely dreamed of a decade ago. And with equal celerity leaders of every activity sense the preponderance of public opinion and act upon it.

Today no financial, political, or other group can do any great damage to the mammoth organization of business by which we all live and enjoy a measure of well-being unequalled in any other country in the world.

Advertising rapidly focuses public opinion, changes buying habits, speeds up the development of efficient products and causes the discontinuance of inefficient products. And yearly, advertising becomes a more effective tool in performing its cost-reducing service to production and distribution.

As one authority puts it, the situation calls for "more steam" on the part of everyone who would enjoy profitable employment of his services, capital, equipment or machinery.

Despite the cold facts of continued excellent conditions, there is a feeling of depression in the minds of many men.

This is accounted for by the fact that there is and always will be a great majority of mankind that want to get "easy money."

In the past decade, all the people and all businesses have enjoyed, at one time or another, a great degree of prosperity, regardless of their comparative efficiency or economy.

Trace this feeling of depression to its various sources, and invariably it comes from plants, stores, industries, offices, and individuals that have failed to maintain and increase the efficiency of their equipment and methods, physical and mental, in proportion to the general advancement made in this country as a whole.

This fact can only result in still greater opportunity for those who follow a course of sound progressiveness. For these there are greater rewards to come than all that have gone before. Nor can effort be spared now by those who are to receive them.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Bethlehem, Pa.
Binks Spray Equip. Co., Chicago.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Sullivan Machy. Co., Chicago.
Worthington Pump & Mach. Corp., New York.
Yeomans Bros. Co., Chicago.

AIR FILTERS
Spray Engineering Co., Boston.

AIR WASHERS
Buffalo Forge Co., Buffalo, N. Y.
New York Blower Co., Chicago.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland.
Wright-Austin Co., Detroit.

ANTI-CORROSIVE COATINGS
Dampney Co. of Am., Boston.

ARCHES, BOILER AND COMBUSTION
Brady Conveyors Corp., Chicago.
Carborundum Co., Perth Amboy.
Denver Fire Clay Co., Denver.
Detrick Co., M. H., Chicago.
Girtanner Engrg. Corp., N. Y.
Harbison - Walker Refract. Co., Pittsburgh, Pa.
Hofft Co., M. A., Indianapolis.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

ASH BIN GATES AND DOORS
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Conveyors Corp. of Am., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.

ASH HANDLING SYSTEMS
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Am., Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.
Link-Belt Company, Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Am., Chicago.

BABBITT METAL
Magnolia Metal Co., New York.

BAROMETERS
Taylor Inst. Co.'s, Rochester, N. Y.

BEARING METAL
Magnolia Metal Co., New York.

BEARINGS
National Tube Co., Pittsburgh.

BELT CONVEYORS
Jeffrey Mfg. Co., Columbus.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELTING
Crandall Pkg., Palmyra, N. Y.
Quaker City Rubber Co., Phila.

BELTING, SILENT CHAIN
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE
Air-Preheater Corp., New York.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
New York Blower Co., Chicago.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT
McClave-Brooks Co., Scranton.
New York Blower Co., Chicago.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PRESSURE
Carling Turbine Blower Co., Worcester, Mass.

BLOWERS, PULVERIZED COAL
Buffalo Forge Co., Buffalo.

BLOWERS, STEAM
Schutte & Koerting Co., Phila.

BLOWERS, TUBE
Diamond Power Spec. Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Vulcan Soot Cleaner Co., Du Bois, Pa.

BOILER SETTINGS
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Denver Fire Clay Co., Denver.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N.Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Rust Engrg. Co., Pittsburgh.
Walsh & Weidner Boiler Co., Chattanooga, Tenn.
Walsh Fire Clay Products Co., St. Louis, Mo.

BOILER TUBE CLEANERS
General Spec. Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Hartford, Conn.

BOILER TUBES
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS
Botfield Refractories Co., Phila.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 154

BLOWERS, TURBINE
Carling Turbine Blower Co., Worcester, Mass.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES
Boiler Engrg. Co., Newark, N. J.
Engineer Co., The, New York.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., N. Y.

BOILER CAP CLEANERS
Lagonda Mfg. Co., Springfield, O.

BOILER CASING
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.

BOILER COATINGS
Dampney Co. of Am., Boston.

BOILER COMPOUND
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N.Y.
Paige & Jones Chem. Co., Inc., New York.

BOILER COMPOUND FEEDERS
Hills-McCanna Co., Chicago, Ill.

BOILER ENGINEERS
Boiler Engrg. Co., Newark, N. J.

BOILER FEED WATER, PURIFYING APPARATUS
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., Inc., New York.
Permutit Co., New York, N. Y.

BOILER FRONTS
McLeod & Henry Co., Troy, N.Y.

BOILER MOUNTINGS
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Harbison - Walker Refract. Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Insulating Products Corp., N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.
Insulating Products Corp., N. Y.

BOILERS
Ames Iron Works, Oswego, N. Y.
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Connelly Boiler Co., The D., Cleveland, O.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie.
Heine Boiler Co., St. Louis, Mo.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.
Wickes Boiler Co., Saginaw.

BRICKS, FURNACE LINING
Norton Co., Worcester, Mass.

BREECHINGS
Connery & Co., Inc., Phila.
Heine Boiler Co., St. Louis, Mo.
Littleford Bros., Cincinnati.

BRUSHES, DYNAMO AND MOTOR
Calebaugh Self-Lubricating Carbon Co., Inc., Philadelphia.
Dixon Crucible Co., Jos., Jersey City, N. J.
LeValley Vitae Carbon Brush Co., New York, N. Y.

BRUSHES, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS
Brady Conveyors Corp., Chicago.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

BUCKETS, COAL HANDLING
Jeffrey Mfg. Co., Columbus, O.

CAR DUMPERS
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET
Jeffrey Mfg. Co., Columbus, O.
Webster Mfg. Co., The, Chicago.

CASTINGS
Erie City Iron Wks., Erie.
Fuller Lehigh Co., Fullerton, Pa.
Girtanner Engrg. Corp., N. Y.
Hills-McCanna Co., Chicago.
Neemes Fdry., Inc., Troy, N. Y.

CEMENT, FURNACE
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Denver Fire Clay Co., Denver.
Harbison - Walker Refract. Co., Pittsburgh.
Insulating Products Corp., N. Y.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., Inc., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT, HIGH TEMPERATURE
Botfield Refractories Co., Phila.
Denver Fire Clay Co., Denver.
Harbison - Walker Refract. Co., Pittsburgh, Pa.
Johns-Manville Corp., New York.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec. Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT, INSULATING
Insulating Products Corp., N. Y.

CEMENT, IRON
Smooth-On Mfg. Co., Jersey City.

CHAIN WHEELS
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHEMICALS, WATER TREATING.
Chicago Chemical Co., Chicago.

CHIMNEYS
American Chimney Corp., N. Y.
Rust Engrg. Co., Pittsburgh.
Springfield Boiler Co., Springfield, Ill.

CIRCUIT BREAKERS
Cutter Co., The, Philadelphia.

CLEANERS, BOILER TUBE
General Spec. Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

CLEANING COMPOUND
Dearborn Chem. Co., Chicago.

COAL AND ASH-HANDLING MACHINERY
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Am., Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago.
Stephens - Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

COAL BUNKERS, CAST IRON, CATENARY
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.

COAL CRUSHERS
Fuller Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., Columbus, O.
Pennsylvania Crusher Co., Phila.
Stephens - Adamson Mfg. Co., Aurora, Ill
Webster Mfg. Co., The, Chicago.
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.

COAL STORAGE EQUIPMENT
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Am., Chicago.
Link-Belt Company, Chicago.
Stephens - Adamson Mfg. Co., Aurora, Ill
Webster Mfg. Co., The, Chicago.